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THE MIDDLE LOBE OF THE RIGHT LUNG

ITS ROENTGEN APPEARANCE IN HEALTH AND DISEASE

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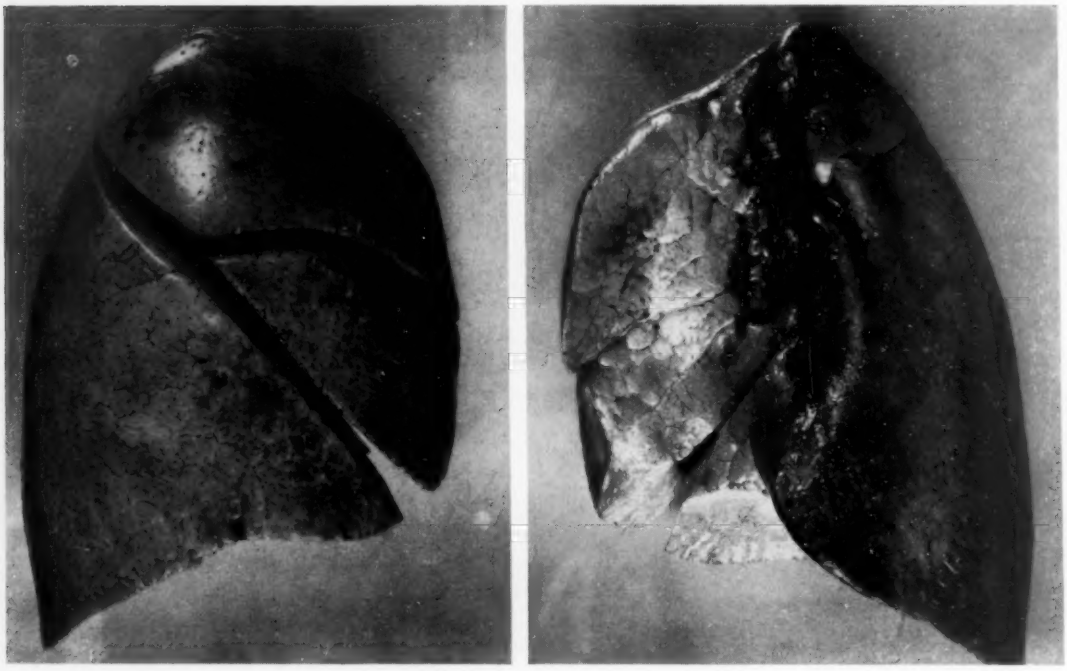
ADVANCES in pulmonary surgery have made it necessary for the roentgenologist to accurately localize pulmonary disease to the lobe involved. This paper will be limited to a comparison of shadows cast by pathological processes in the right middle lobe, with the surgical and necropsy findings. Fifty-six patients suffering with disease of the middle lobe were studied. Of this number 41 were proved either by surgery or autopsy. The remaining 15 patients have had bronchoscopy or lipiodol injection.

Particular attention will be paid to the right lateral view of the chest. No attempt will be made to evaluate or discuss various other necessary methods of examination such as stereoscopic, "Kreuzhohlstellung" (posteroanterior views with the patient in extreme lordosis), oblique views, or films taken at various phases of respiration. Secondary compensatory changes in the chest such as alterations of the diaphragm, shift in the mediastinum, emphysema, blood vessel changes, alteration of the thoracic cage, etc., as well as the clinical aspects, will be discussed more completely in a later paper. It is hoped that this work may aid in the interpretation of certain shadows seen in the lower portion of the right side of the chest which are now commonly and vaguely termed as right perihilar thickening, peribronchial fibrosis, right hilar tuberculosis, pleuropericardial disease, thickened interlobar pleura, pleurisy at anterior costophrenic angle with interlobar extension, increase in lung markings, diminished radiance, mottled dullness, and, most common, interlobar effusion. Our presentation is divided into three parts. Part I includes a brief anatomic description of the normal lung and of some of the more common shadows cast by disease in the middle lobe. Part II deals with shadows simulating encapsulated interlobar empyema and emphasizes some points in differential diagnosis. In Part III some of the more unusual shadows cast by a fibrosed or collapsed middle lobe will be presented. The effect of pleural adhesions upon the shape of these shadows will be discussed.

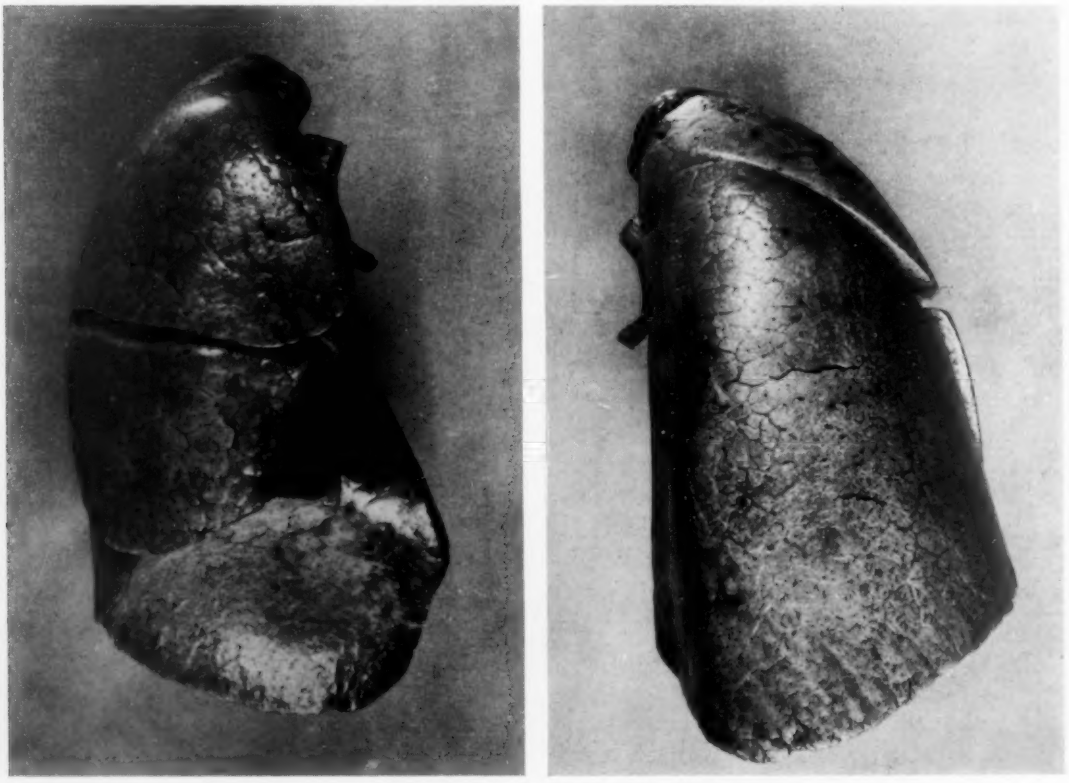
PART I. THE MORE COMMON SHADOWS CAST BY DISEASE OF THE MIDDLE LOBE AND THE ANATOMY OF THE NORMAL MIDDLE LOBE

In Figure 1 particular attention is directed to the *triangular* shape of the lateral aspect and the *rectangular* shape of the medial aspect of the middle lobe. The apex of the triangle is opposite the lung root and the mid-axillary line, whereas the base is in contact with the anterior chest wall from the fourth rib to the diaphragm. The base of this triangle is slightly exag-



a *b*

FIG. 1. A previously inflated and dried specimen of a normal right lung. *a*. Note triangular shape of lateral surface of middle lobe. *b*. The medial surface of the middle lobe is rectangular and is normally in contact with the right border of the heart.



a *b*

FIG. 2. Same specimen as in Figure 1; *a*, anterior surface; *b*, posterior surface.

gerated by over-inflation, but an average normal measurement is approximately 8 cm. It is important to note that the septum between the upper and middle lobes (Fig. 1, *a*) is convex upward, and that the septum between the middle and lower lobes definitely intersects the diaphragm about 4 cm. posterior to the anterior costophrenic angle. These septa are commonly seen in the lateral view of a normal chest.

The mediastinal surface of the middle lobe (Fig. 1, *b*) is only slightly smaller than the lateral surface, and measures about 6 cm. Its general shape is definitely rectangular. This portion of the middle lobe outlines the right border of the heart, whereas the lower lobe is in contact with the heart only slightly. One would expect therefore that density in the medial aspect of the middle lobe would obscure the right border of the heart. Since the medial aspect of the right anterior costophrenic angle and

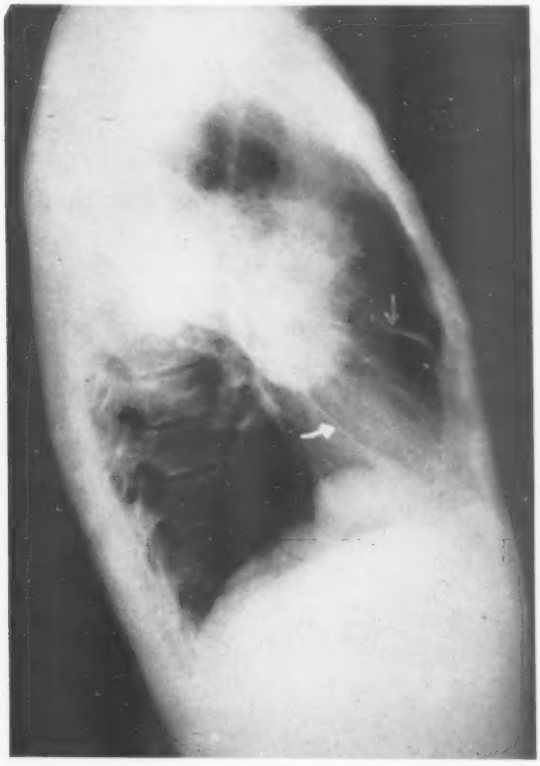


Fig. 3. Selected to show normal size, shape and position of the middle lobe in the right lateral view.

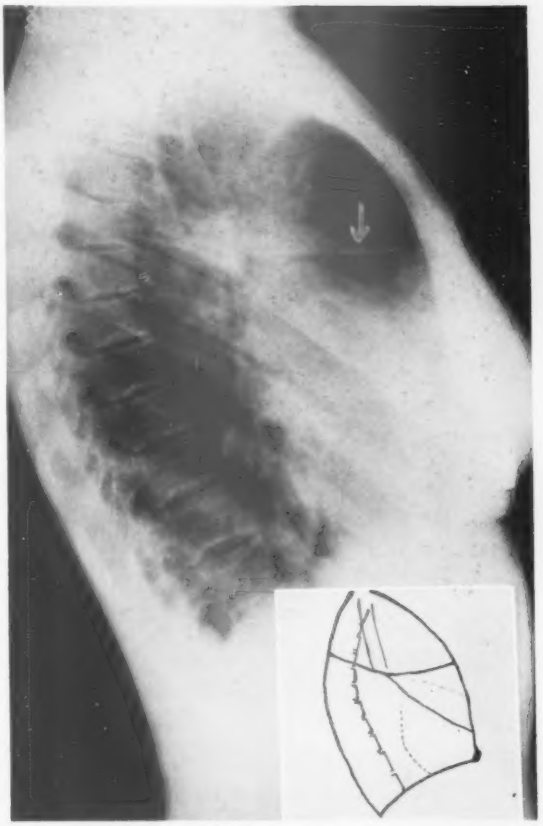
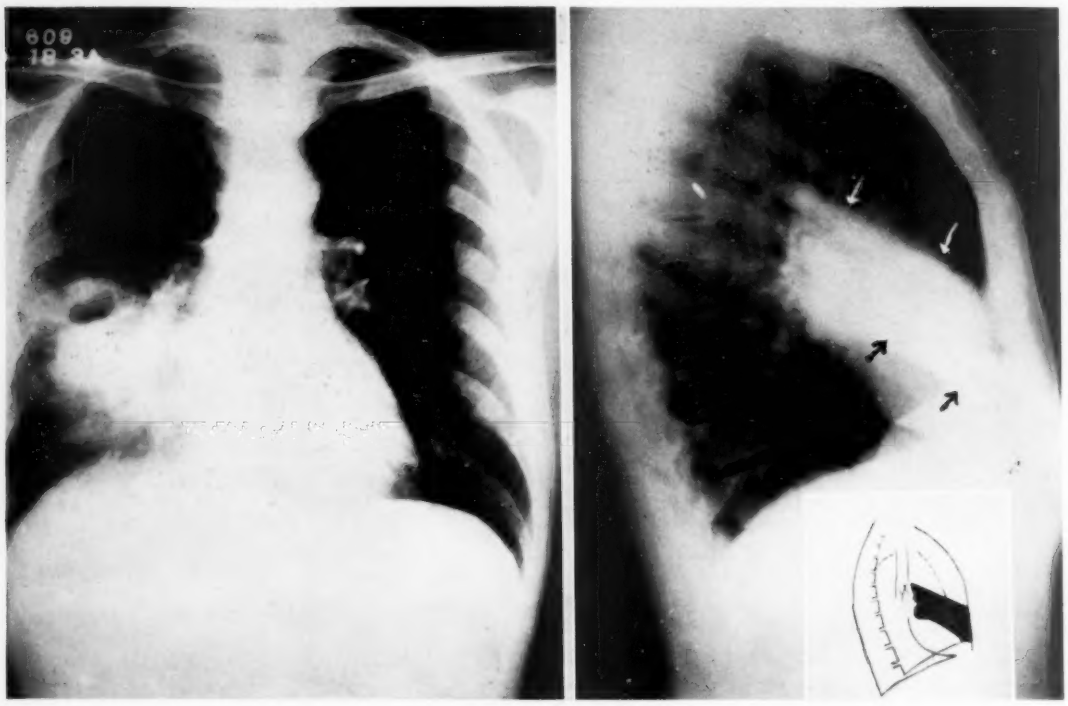


Fig. 4. Middle lobe displaced upward due to fibrosis and bronchiectasis of the upper lobe. There is slight involvement of the middle lobe. (Necropsy.)

the right cardiophrenic angle is occupied normally by the middle lobe, it is also logical to expect that shadows obliterating these angles may be due to disease in the middle lobe or its pleural surface. In the posteroanterior view the maximum densities produced by complete consolidation of the middle lobe are seen just below the septum between the middle and upper lobes. The consolidation shadows gradually become less dense as the right costophrenic angle is approached. In other words, maximum densities are seen where and when the central beam of the roentgen tube is perpendicular to the thickest part of the lobe. The lateral projection of the middle lobe casts a shadow of fairly even density due to its uniform thickness in this direction.

In Figure 2, *a*, the septum between the upper and middle lobes is horizontal and



a *b*

FIG. 5. Posteroanterior (*a*) and lateral (*b*) roentgenograms showing rectangular shadow (normal size) due to disease in the medial aspect of the middle lobe. (Pneumonectomy for carcinoma of the right middle lobe bronchus.)

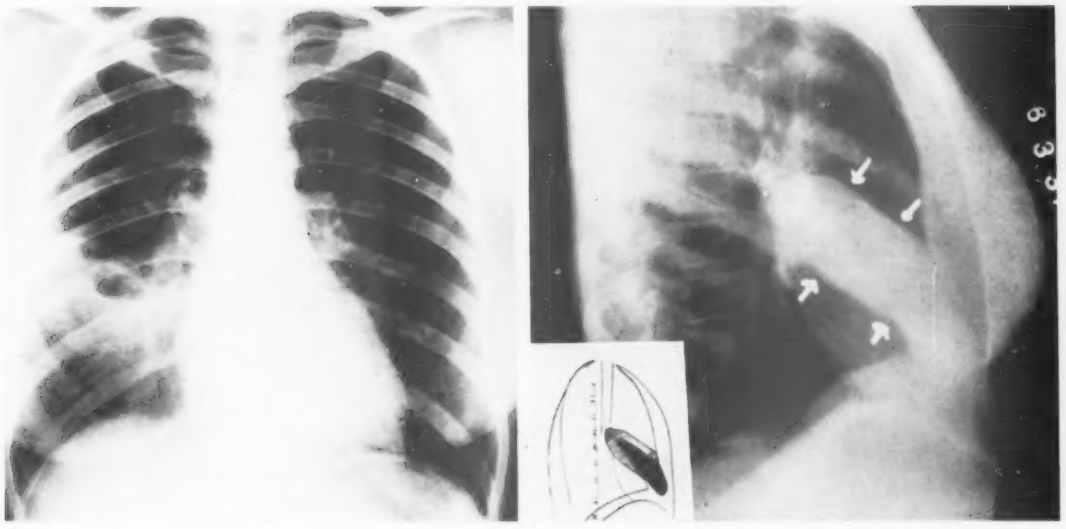
extends from the axillary line to the right border of the heart. This septum is also commonly seen crossing the anterior end of the fourth rib in routine roentgenograms of the chest. The lateral costophrenic angle is occupied by the lower lobe. The middle lobe does not reach the chest wall at the lateral costophrenic angle, but ends in a convex line about 3 cm. above and medial to it, so that in the presence of density in this portion of the middle lobe the costophrenic angle remains clear. The medial margin of the middle lobe conforms to the shape of the right side of the heart.

In Figure 2, *b*, the lower lobe occupies the greater portion of the posterior surface of the right lung. The middle lobe is not visible.

In Figure 3 the middle lobe is clearly defined by thickened septa, due to lung abscess and encapsulated empyema of the right upper lobe. The septa are more clearly seen than usual due to disease. (Rib resection and drainage.)

As has been previously mentioned, disease in the lateral aspect of the middle lobe may produce a triangular shadow, whereas disease in the medial aspect may produce a rectangular shadow. In Figure 5, *a*, a rounded area of density obscures the right border of the heart. The right cardiophrenic angle is seen. The upper margin of the shadow is opposite the fourth rib in front, and there is a cavity in its lateral margin. Note that the lateral portion of the middle lobe is clear.

The striking feature of the lateral view (Fig. 5, *b*) is the dense rectangular shadow superimposed upon the heart. This shadow corresponds closely to the shape and size of the normally expanded mediastinal aspect of the middle lobe. A right pneumonectomy was done, and a tumor of the middle lobe bronchus was found. The shape of the medial aspect of the middle lobe compared exactly with the roentgenogram, measuring 6 cm. in thickness and 11 cm. in length. The gross appearance of the



a *b*

Fig. 6. Posteroanterior (*a*) and lateral (*b*) roentgenograms showing rectangular shadow (slightly reduced), with indistinct triangular shadow superimposed. (Lung abscess in middle lobe—rib resection and drainage.)

medial portion was that of the "drowned" lung. There were pleural adhesions over the upper anterior surface of the lateral aspect of the lobe, and the lower lateral aspect was free and atelectatic.

The posteroanterior view (Fig. 6, *a*) shows an obliterated right cardiophrenic angle, haziness of the right border of the heart, density which fades out downward and to the right, ending above in a sharp horizontal line at the fourth rib. There is a cavity in the upper central portion of the diseased area.

The lateral view (Fig. 6, *b*) demonstrates a rectangular shadow extending from the lung root to the anterior chest wall, and superimposed upon it (seen only in the original film) there is a definite small triangle corresponding to the general shape of the lateral portion of the middle lobe. The rectangle is smaller than the normal middle lobe (about five-eighths). At operation an egg-shaped cavity was found within the middle lobe, and 3 c.c. of pus was discovered in the pleural cavity adjacent to the abscess.

The lateral roentgenogram of the chest in Figure 7 is selected to show more clearly the rectangular shadow which may be seen accompanying disease of the middle lobe. The rectangle is well outlined by lipiodol, and numerous, closely placed, dilated bronchi are seen. The density in the posterior aspect of the chest is due to bronchiectasis of the left lower lobe.

In the posteroanterior view (Fig. 8, *a*) the diaphragm, cardiophrenic angle, right border of the heart and medial aspect of

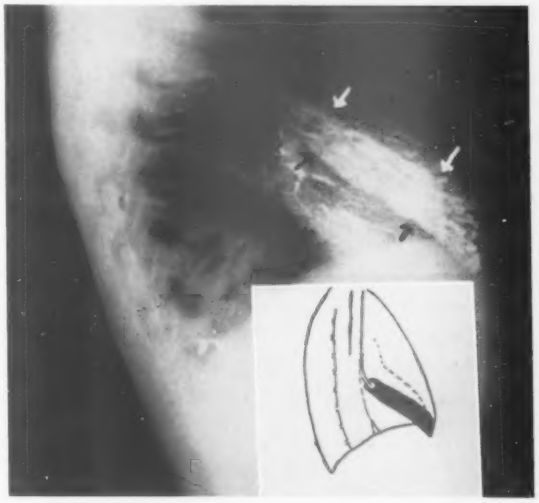
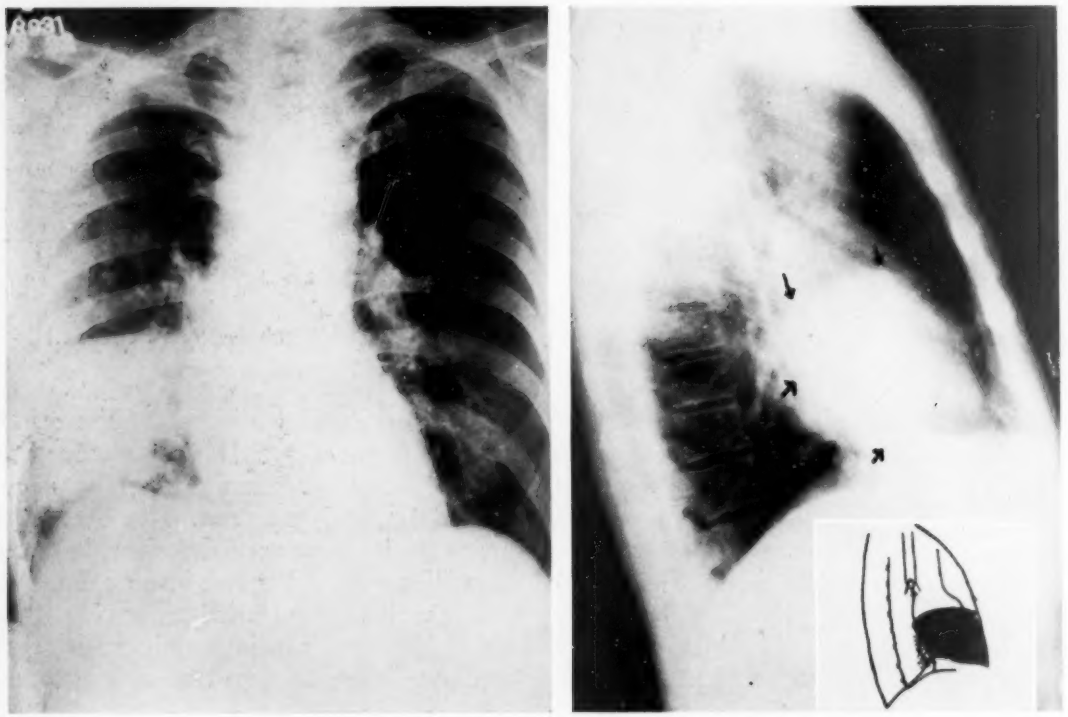


Fig. 7. Rectangular shadow, one-half normal size, due to advanced bronchiectasis right middle lobe. (Left lower lobe also involved—lipiodol injection.)

the middle lobe area are clear. The area of density occupies the usual position of the lateral three-fourths of the middle lobe.

In the lateral projection (Fig. 8, *b*) the shadow is identical in shape with the lateral aspect of the normal middle lobe except that the septum between the middle and lower lobes is slightly convex instead of straight. This convexity was due to consolidation.



a *b*

FIG. 8. Posteroanterior (*a*) and lateral (*b*) roentgenograms selected to show triangular shadow of the usual size and shape of the lateral aspect of the middle lobe. At necropsy the lateral three-fourths of the middle lobe was consolidated due to lobar pneumonia. Tuberculosis was present in the upper lobe.

In Figure 9 the interlobar septa curve toward each other in contrast to Figure 8. The middle lobe is reduced to about half its normal size. There is marked anterior displacement of the lower septum. The lower lobe has enlarged as a result of the reduction in size of both the upper and middle lobes.

PART II. SHADOWS SIMULATING INTERLOBAR EFFUSION

Béclère in 1899 and Holzknecht in 1901 first described a technique for the discovery of interlobar disease. This technique consisted of "raising the tube and lowering the eye" during the roentgenoscopic observation.[5] Their original work stimulated Fleischner[2] to a more complete study of interlobar disease. He developed a special position (Kreuzhohlstellung) whereby the superior and inferior septa of the middle lobe and the septum between the upper lobes were projected as nearly on edge as possible. This pose of the patient in extreme lordosis with the tube posteriorly is well known and of inestimable value. Unfortunately, Fleischner attributed all the shadows thus demonstrated to disease in the pleura, although he did mention the possibility of error which might be caused by a small consolidated middle lobe. Kopstein[3] in 1929 also mentioned this possibility of error, but it was not until 1933 that he[4] first attempted to differentiate between interlobar and lobar disease by the use of the Kreuzhohlstellung position. His valu-

able contributions should be read in detail. His work is based upon comparative anatomical and pathological studies of the commonly called "perihilar densities," and the importance of middle lobe disease in the production of these shadows was emphasized. Four post-mortem cases were presented and several clinical observations were made. By the use of the Kreuzhohlstellung position he demonstrated a wedge-shaped shadow, with its base at the mediastinum and its apex pointing toward the axillary line, which in the cases presented was not due to interlobar disease. Kopstein believes that it is possible to prove disease in the middle lobe by this method when other methods give insufficient information, and that it is also possible thus to analyze these disease processes. However in certain cases he found it nearly impossible to differentiate between lobar and interlobar disease. He did not present a single proved instance of primary encapsulated interlobar empyema. He advised the Kreuzhohlstellung position in preference to the lateral view, and showed comparative studies which were fairly convincing. We regret that we have not used this view sufficiently to allow us an accurate evaluation of it. Assmann,[1] however, believes that the lateral view is of more value than the Kreuzhohlstellung position in the study of middle lobe disease.

Our interest in interlobar processes, particularly encapsulated interlobar empyema, was first stimulated by negative operative findings on a patient whom we believed by clinical and roentgenographic studies to have had pus between the middle and lower lobes. We directed the surgical approach by marking the skin over a fusiform shadow in this area. Although two surgical explorations were done no fluid was found. Similar experiences followed, and as a result we are unable to report an example of primary encapsulated interlobar empyema in the region of the middle lobe. It is well known that interlobar extensions of pleural effusions are fairly common, but we wish to emphasize that such effusions should not be confused with primary encapsulated interlobar empyema.

It was our impression until the completion of this work that most roentgen diagnoses of encapsulated interlobar fluid were inaccurately interpreted by the operating surgeon as lung abscesses. This assumption probably accounts for the fact that more progress has not been made in establishing accurate criteria for the diagnosis of inter-

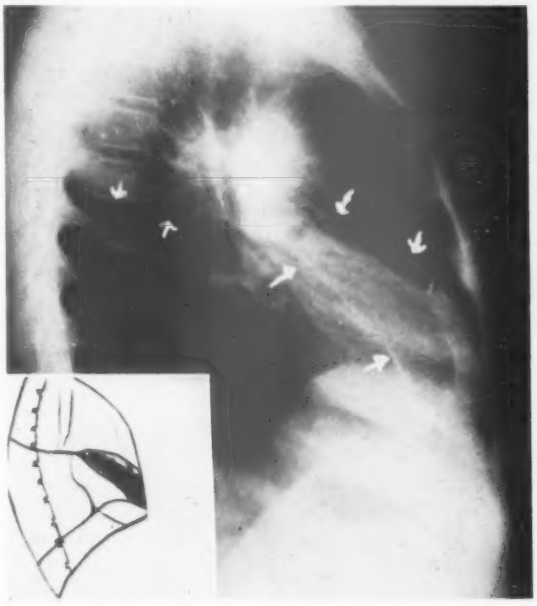


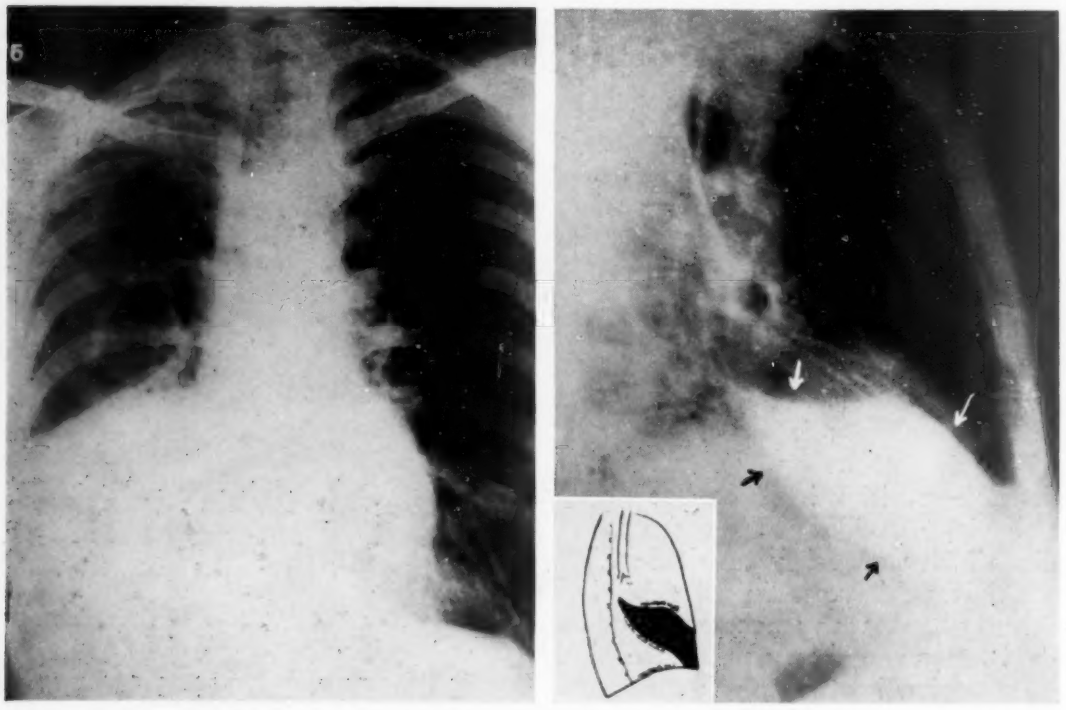
Fig. 9. Reduced triangular shadow. Nine months after drainage of lung abscess at anterior axillary line. There is also an old abscess in the center of the upper lobe.

lobar empyema. Recently we have worked with the surgeon in an attempt to determine accurately whether a disease process found at operation was actually within the lung or between the pleurae. Realizing the complexity of the pathological process, the location and amount of pus discovered at operation were recorded in each instance, and the cavity was carefully inspected to determine whether its walls were lined with pulmonary or pleural tissue. As a result of these studies we have found that lung abscess is far more common than primary encapsulated interlobar empyema.

In view of the fact that a definite roentgen diagnosis of primary encapsulated in-

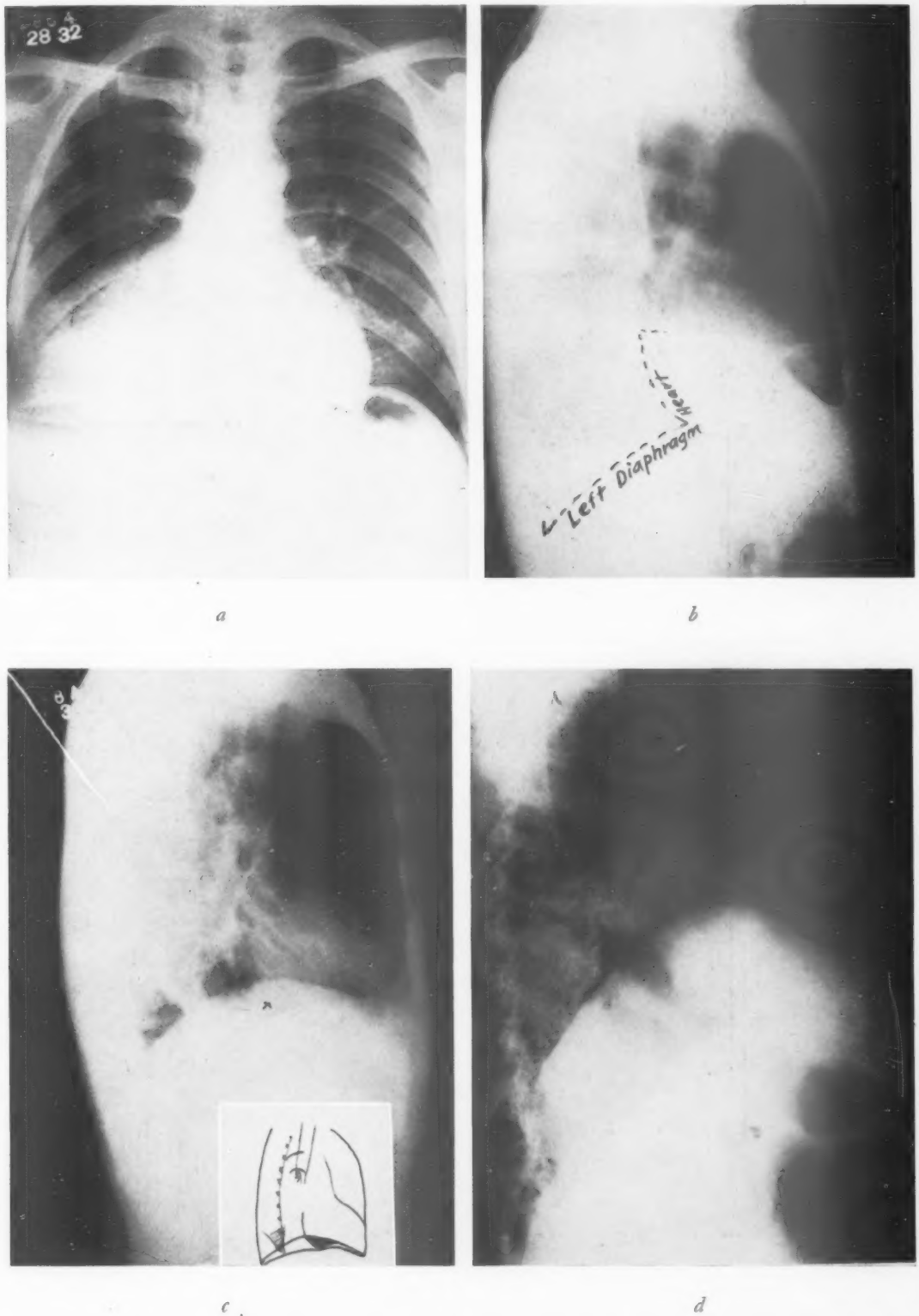
terlobar empyema in the region of the middle lobe septa is extremely difficult to make, the clinical aspects of this disease must be given primary consideration. The roentgenologist is commonly asked to examine the chest of a patient following drainage of an empyema to determine the cause of persistent fever. Under these circumstances, any shadow simulating interlobar fluid is likely to be interpreted as encapsulated empyema, and we wish to *emphasize that such encapsulations are rare*. The following group of cases is presented to illustrate shadows which may be misleading and erroneously diagnosed as effusions because of their fusiform shape. The most common of this type of shadow is the "overlap." It is seen in the lateral projection and is produced by superimposed heart and right diaphragm. The shadow produced by collapse of the middle lobe may be fusiform in shape. It must also be remembered that a postoperative chest may present a complicated picture of superimposed or overlapping shadows.

The mechanism of the production of the overlapping shadow is well illustrated in Figure 10, *a* and *b*. The right side of the diaphragm is elevated and obscured in its posterior half. The left side of the diaphragm is distinct and low in position. The convex superior margin of the fusiform overlapping shadow is produced by the visible portion of the right side of the diaphragm, whereas the convex inferior margin is produced by the border of the heart as outlined by the aerated left lung. The diaphragmatic and cardiac shadows often superimpose in the lateral view to produce fusiform overlapping shadows, but so long as the entire arc of each side of the diaphragm is distinctly seen little confusion results. The degree of overlap is determined by the position of the right side of the di-



a *b*

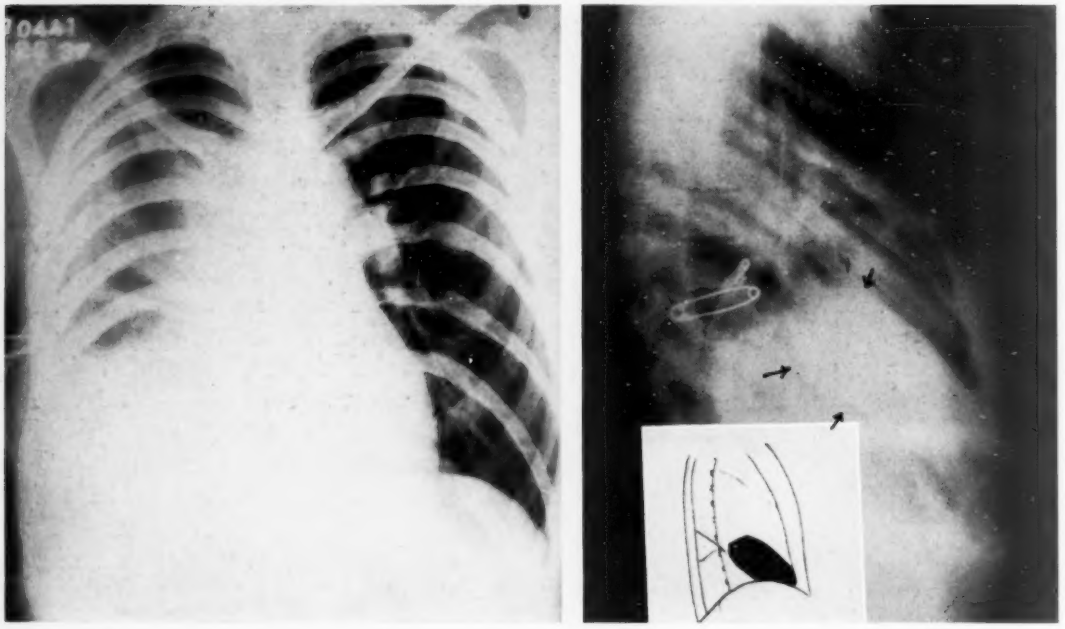
FIG. 10. Posteroanterior (*a*) and lateral (*b*) roentgenograms selected to show the overlapping shadow. (Phrenicotomy for tuberculosis of the right upper lobe and lower lobes. No interlobar disease.)



a *b*

c *d*

FIG. 11, *a*, *b*, *c* and *d*. Overlapping shadow due to suppurative disease of the right lower lobe erroneously interpreted as interlobar effusion. No operative procedure necessary for clinical cure.

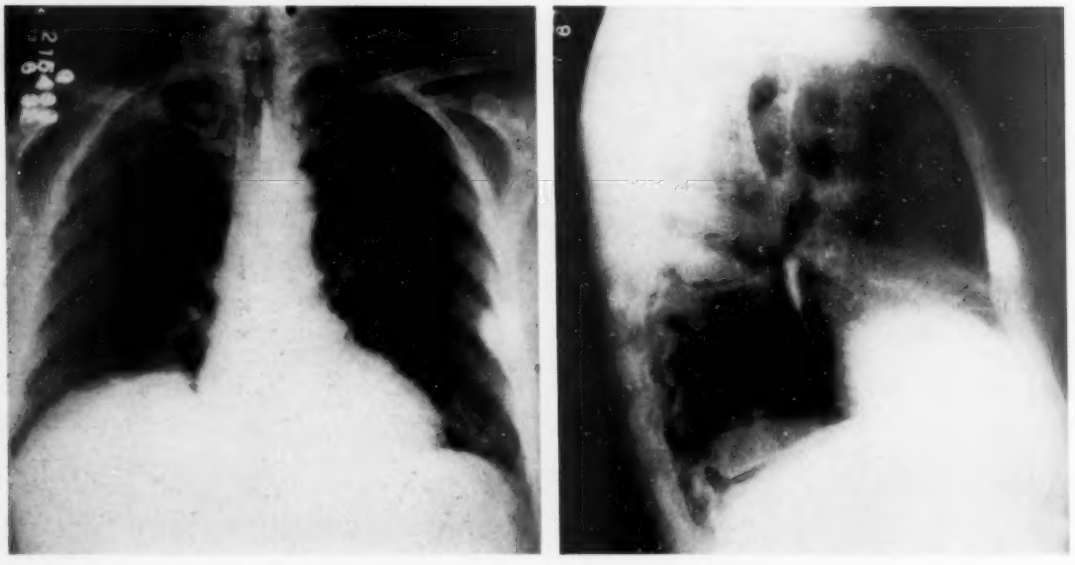


a *b*

FIG. 12. Anteroposterior (*a*) and lateral (*b*) roentgenograms showing overlapping shadow due to high right diaphragm following trocar thoracotomy for empyema. Second operation necessary for adequate drainage of original empyema cavity. No interlobar disease.

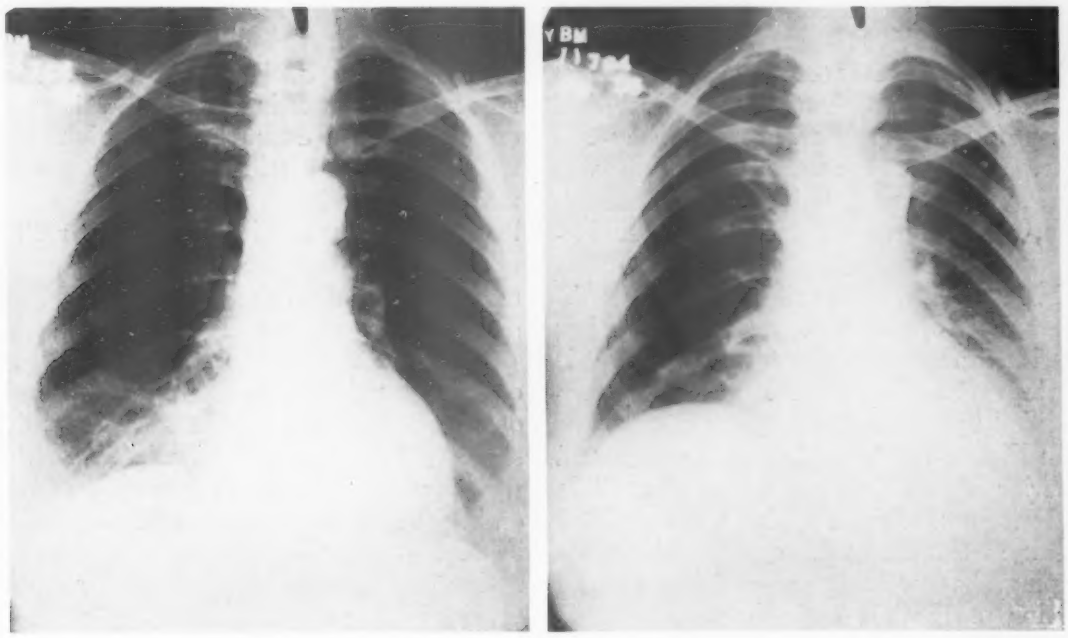
aphragm, or the distortion produced in taking the roentgenogram.

The posteroanterior view (Fig. 11, *a*) shows a triangular area of density which appears to obscure the right side of the diaphragm, but the right border of the



a *b*

FIG. 13. Posteroanterior (*a*) and lateral (*b*) roentgenograms selected to show overlapping shadow as a result of elevation of anterior half of the right diaphragm. Operation showed necrotic tumor of the liver with adhesions of the diaphragmatic pleura. No pulmonary or interlobar disease.



a *b*

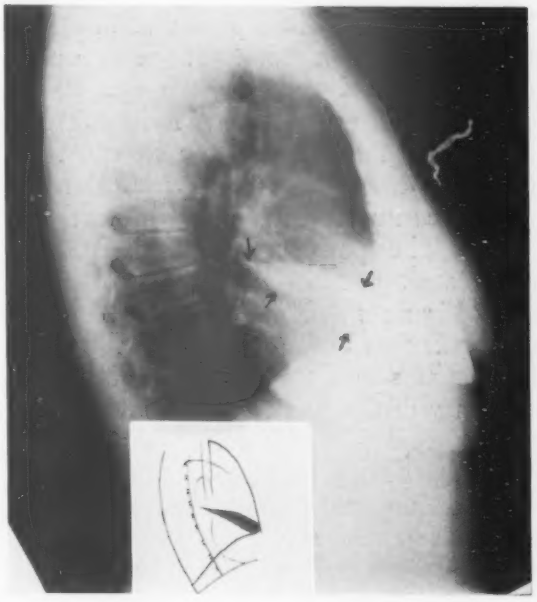
Fig. 14. Collapse of the right middle lobe with obstructive emphysema of the right lower lobe; *a*, taken at full inspiration; *b*, taken at full expiration.

heart shadow is fairly distinct, indicating that the anterior portion of the right lung is clear.

Figure 11, *b* (40″ portable film centered in the region of the axilla) projects the left diaphragm considerably below the right. The posterior half of the right diaphragm is obscured and the anterior half is distinctly seen. The inferior and superior convexities of the "overlap" are again produced by the heart and diaphragm respectively. The posterior limit of the fusiform shadow is below the usual position of the septa. The interlobar septa are not visible in either Figure 11, *a* or 11, *b*.

Figure 11, *c* (7′ right lateral view) shows less distortion of the position of the diaphragm, with the result that the overlap shadow has almost completely disappeared. The posterior portion of the right diaphragm is now fairly distinct, due to resolution of the disease in the right lower lobe.

Figure 11, *d* (same patient with roentgenogram taken with the same technique as in Figure 11, *b*). Here the overlapping shadow is again present, but the posterior half of the right diaphragm is distinct and the superior convexity can be identified readily as due to the anterior portion of the



c

Fig. 14, *c*. Same as Figure 14, *a*, right lateral view. The collapsed middle lobe simulates thickened interlobar pleura.

right diaphragm; therefore, less confusion results.

This case is presented because of the fact that though the patient had all the clinical symptoms of suppurative pulmonary disease, and the roentgen diagnosis was originally encapsulated interlobar empyema, the subsequent clinical course disproved this diagnosis.

In Figure 12, *a*, the right side of the diaphragm is opposite the tenth rib; the left side is at the twelfth rib. A drainage tube is at the seventh interspace posteriorly surrounded by air in an empyema cavity.

In Figure 12, *b*, the left diaphragm and anterior half of the right are distinct. The posterior half of the right is poorly outlined by air in the empyema cavity. The overlapping shadow is again produced by the portion of the left side of the heart outlined by the left lung and the anterior half of the right side of the diaphragm outlined by the right lung.

Due to the clinical course of this patient, after trocar thoracotomy, it was thought that undrained pus was present, and further roentgen examination revealed a fusiform shadow as seen in Figure 12, *b*. This shadow was interpreted as interlobar empyema. At operation a rib resection was done at the site of the drainage tube and a small quantity of undrained fluid was found in the original cavity. No attempt was made to drain an interlobar effusion and there was no further clinical indication of sepsis. The patient was discharged ten days later.

In Figure 13, *a* and *b*, the differential diagnosis was between interlobar effusion, lung tumor and tumor in the liver. The visibility of the normal interlobar septa in the original films immediately ruled out interlobar disease. The mechanism producing the overlapping shadow is quite plainly demonstrated.

Shadows actually produced by disease in the middle lobe which may be erroneously interpreted as pleural disease are numerous and the various examinations sometimes necessary for a differential diagnosis are well illustrated in Figure 14, *a*, *b*, *c*, *d* and *e*.

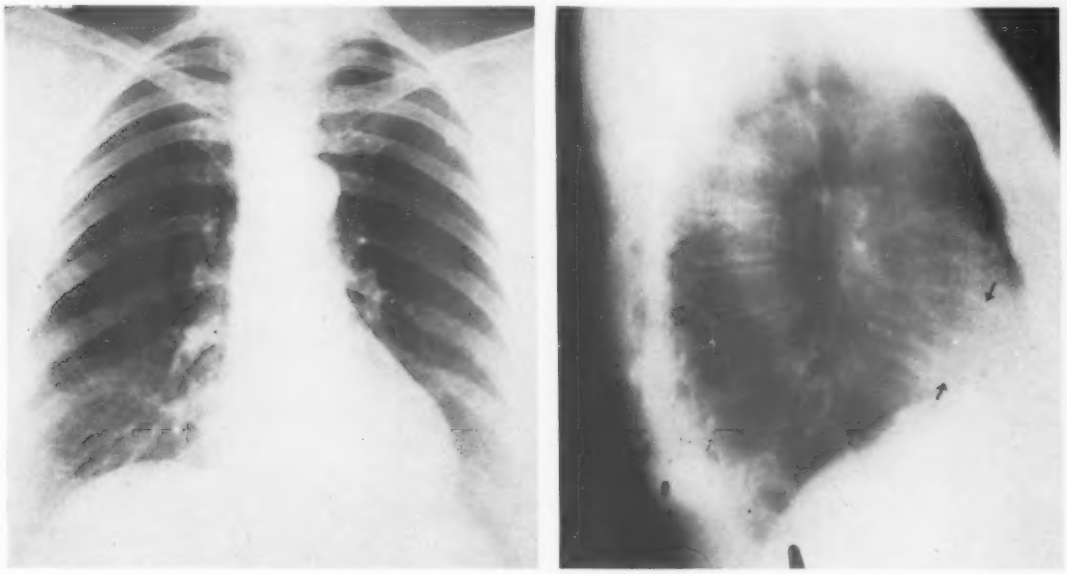
In Figure 14, *a*, the diaphragm is visible and normal in outline. There is a hazy indefinite area of dullness at the right base which is roughly triangular in shape and most dense at the cardiophrenic angle. The breast shadows complicate the picture. The upper portion of the right lung appears more radiant than the left. The heart and mediastinum are normal in position.

Figure 14, *b*, is the same as Figure 14, *a*, except that the film was taken at the end of expiration. Note that the heart has shifted slightly toward the left and that the diaphragm has moved upward equally on both sides. The apices and infraclavicular regions are of equal density, but in the region of the lower lobes the right side is considerably more radiant than the left. The septum between the upper and middle lobes is not seen.

Figure 14, *c*, a right lateral teleroentgenogram, demonstrates a partially fusiform shadow with a convex superior and a straight inferior margin. The convexity corresponds to the normal shape of the base of the upper lobe and the inferior margin is a straight line parallel to the usual course of the septum between the middle and lower lobes. The anterior tips of the upper and lower lobes are clearly seen and are normal in shape. The fusiform shadow extends from the region of the main bronchus of the middle lobe to the anterior costophrenic angle. Note that the posterior limit of the area of density ends abruptly at the anatomical location of the junction of the middle lobe fissures (i.e., at the lung root), and that the septum between the upper and lower lobes is not thickened, in contrast to what one would naturally expect in the presence of pleural disease. Particular attention is also directed to the location of the shadow, i.e., it lies approximately in the center of the area usually occupied by the middle lobe instead of in the region of either the upper or lower septum, as one would expect if the process were primary within the pleura.

The diagnosis made on the three preceding roentgenograms was collapse of the right middle lobe with ball-valve emphysema of the right lower lobe. The patient was a woman, aged fifty-two, complaining of sudden massive hemoptysis, occurring three days previous to the examination. The roentgen diagnosis was tumor of the middle lobe bronchus. It was thought that this tumor had extended to project into the lower lobe bronchus producing a ball-valve obstruction. At bronchoscopy the upper lobe bronchus was normal. The mucosa of the lower lobe bronchus was thickened and red. A few clots of blood projected into it from the middle lobe bronchus. The middle lobe bronchus was entirely occluded by a blood clot which was removed. No definite tumor was found, and a biopsy of the most abnormal part of the mucosa of the middle lobe bronchus was reported as chronic inflammatory disease.

Figure 14, *d*, shows the same patient three days after bronchoscopy with subsequent clinical improvement. The septum between the middle and upper lobes is now distinctly seen. It crosses the anterior end of the fifth rib obliquely downward, and is therefore about one and a half intercostal spaces lower than normal. On these findings alone we would suspect reduction in the size of the middle lobe. Conversely, if the septum were displaced upward we would expect reduction in the size of the upper lobe. The shadow at the right base is less dense and has changed in shape. The lungs are about equal in radiance.



d *e*

Fig. 14, *d* and *e*. Same as Figure 14, *a*, *b* and *c*, but one week following bronchoscopic removal of blood clots in middle lobe bronchus. The middle lobe has partially re-expanded and the septa are visible.

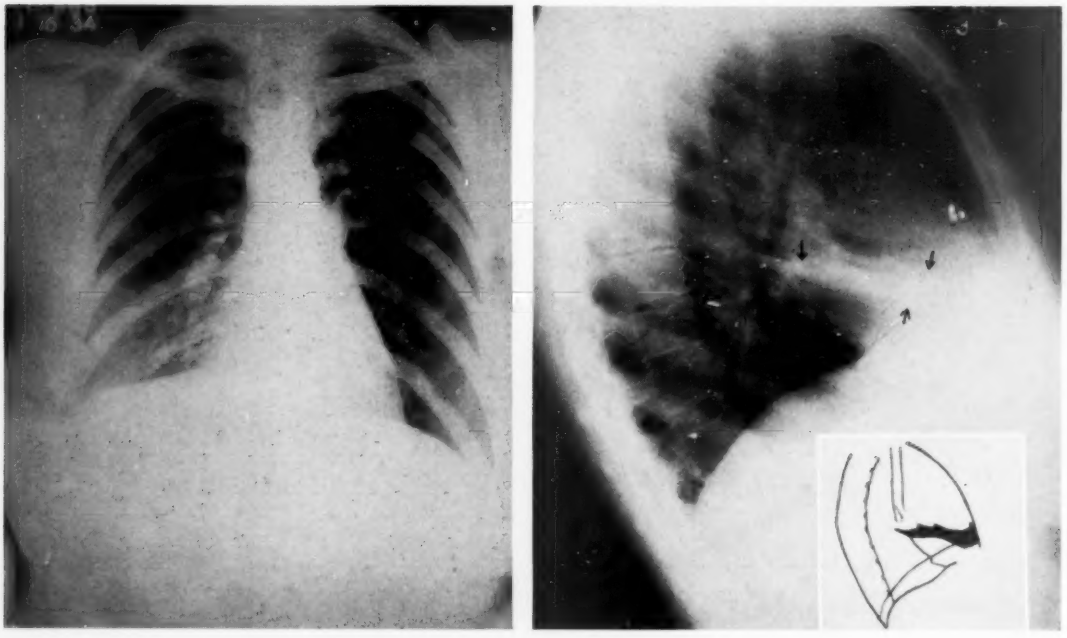
Figure 14, *e*, lateral view following bronchoscopy, shows the superior and inferior septa of the middle lobe distinctly. The homogeneous fusiform shadow has disappeared and is replaced by a few indefinite lines running in the general direction of the middle lobe bronchi. The superior septum is still convex upward whereas the inferior septum is straight. The middle lobe is about one-half expanded.

If this patient follows the usual course of primary malignancy of the middle lobe bronchus we expect her to return in a short time with a recurrence of bleeding and collapse of the middle lobe. Repeated bron-

choscopic examinations are often necessary for accurate study of the middle lobe bronchus because of its relative inaccessibility. Lobar ball-valve emphysema may be produced by any process which narrows a bronchus slightly, and it is assumed that in this case either blood or inflammatory edema were the mechanical factors affecting the lower lobe bronchus.

scars. It is therefore likely that the roentgenologist who insists on interpreting various linear, fusiform, hazy and other shadows in the region of the middle lobe as due to pleural disease, or plumonary fibrosis, will often misinterpret primary middle lobe disease.

The size, shape and position of the collapsed middle lobe may also be dependent



a *b*

FIG. 15, *a* and *b*. Selected to show the effect of pleural adhesions over the medial and lateral aspects of a collapsed middle lobe. (Lobectomy for chronic bronchiectasis localized to middle lobe.)

PART III. MIDDLE LOBE COLLAPSE AND SOME OF THE MORE UNUSUAL SHADOWS CAST BY IT

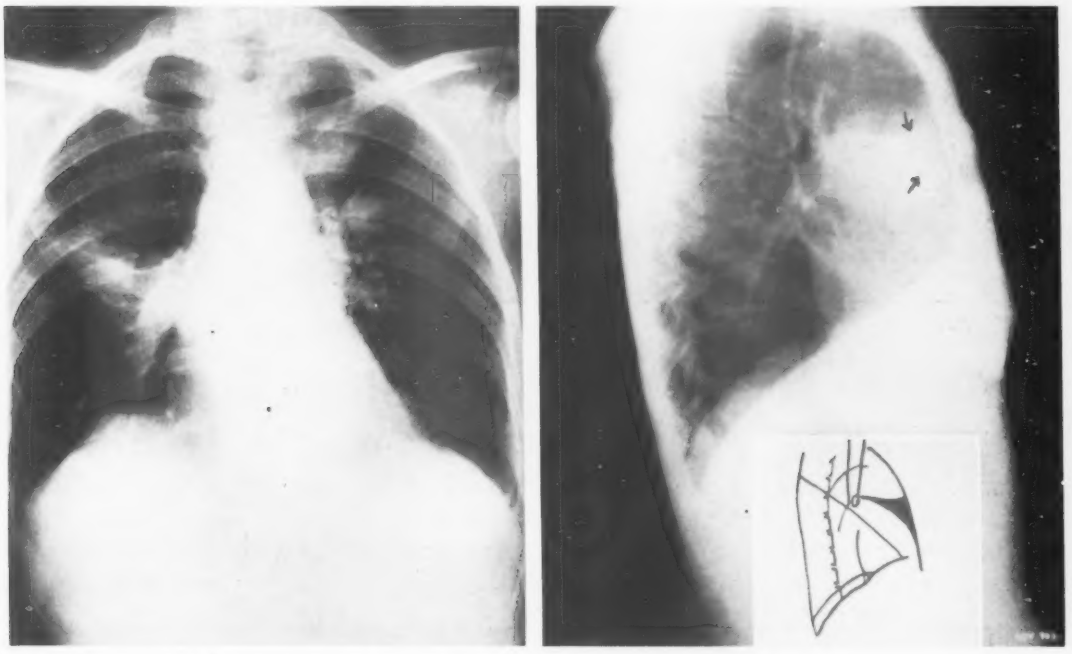
Since the middle lobe is so situated that roentgen shadows of it may be obtained in almost any projection, it follows that an infinite number of shadows can be obtained of the lobe due to any one pathological process. Frequently this lobe is so completely collapsed, or fibrosed, that it is no more than 2 centimeters thick and resembles a pancake in the lateral view, whereas at other times adhesions may so distort a small collapsed lobe that it resembles rather spongy, irregular linear

upon pleural adhesions which existed before collapse occurred, even if standard positions for examination are used. If one views the collapsed middle lobe which is produced by air in the pleural cavity in the ordinary posteroanterior view and in the absence of pleural adhesions, it is seen as a rounded mass in the region of the main bronchus. It would appear that primary collapse due to bronchial obstruction would produce this picture if no adhesions were present. An ideal situation for such a picture would probably be encountered in postoperative massive collapse of the middle lobe. Such uncomplicated primary collapse

of the middle lobe, however, is rare, and other diseases producing collapse are almost invariably accompanied by pneumonitis and pleural adhesions. Pleural adhesions may be present at any or all surfaces. When these adhesions are localized to the interlobar fissure, very little distortion is produced because of the flexibility of the regional lung. In contrast to this, when the adhesions occur over the mediastinal, diaphragmatic, anterior or lateral surfaces the shadow cast by the collapsed middle lobe may be found extending from the point of adhesions to the lung root. This accounts for usually placed and irregularly collapsed middle lobe shadows.

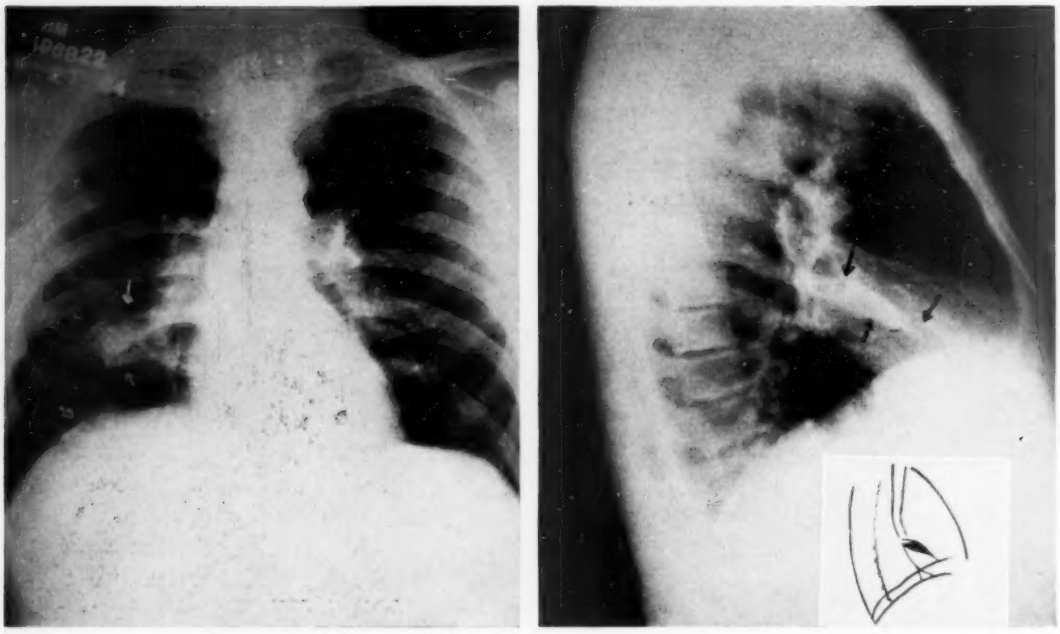
Demonstration of these shadows is usually possible in either of the standard posteroanterior or lateral views, but extreme lordosis, oblique, and roentgenoscopic observations may be necessary, and, as in the previous cases, the demonstration of the interlobar septa is of extreme importance. A knowledge of the compensatory changes and secondary signs of lobular collapse is also of considerable value. Any variation in pulmonary density in the region of the middle lobe warrants a complete search for primary middle lobe disease. In spite of a complete examination, utilizing all methods at one's disposal, the final etiologic diagnosis probably depends upon bronchoscopic examination or lipiodol injection. The supraglottic injection of lipiodol is a valuable and practical aid in diagnosis. Occluded bronchi thus demonstrated should be further examined by bronchoscopy, although suppurative disease of the middle lobe can often be diagnosed without the aid of either lipiodol or bronchoscopy.

The posteroanterior view (Fig. 15, *a*) shows the lateral aspect of the right base



a *b*

Fig. 16, *a* and *b*. Selected to show the size, shape and position of a collapsed middle lobe in the presence of broad pleural adhesions over the anterior surface. Necropsy showed pleural adhesions at the middle of the anterior margins of each lung, 5 × 10 cm. on the right and 3 × 5 cm. on the left. The middle lobe was wedge-shaped, the apex pointing backward. It was filled with dilated bronchi and a benign stricture was present at the main bronchus. The stricture was thought to be due to syphilis.

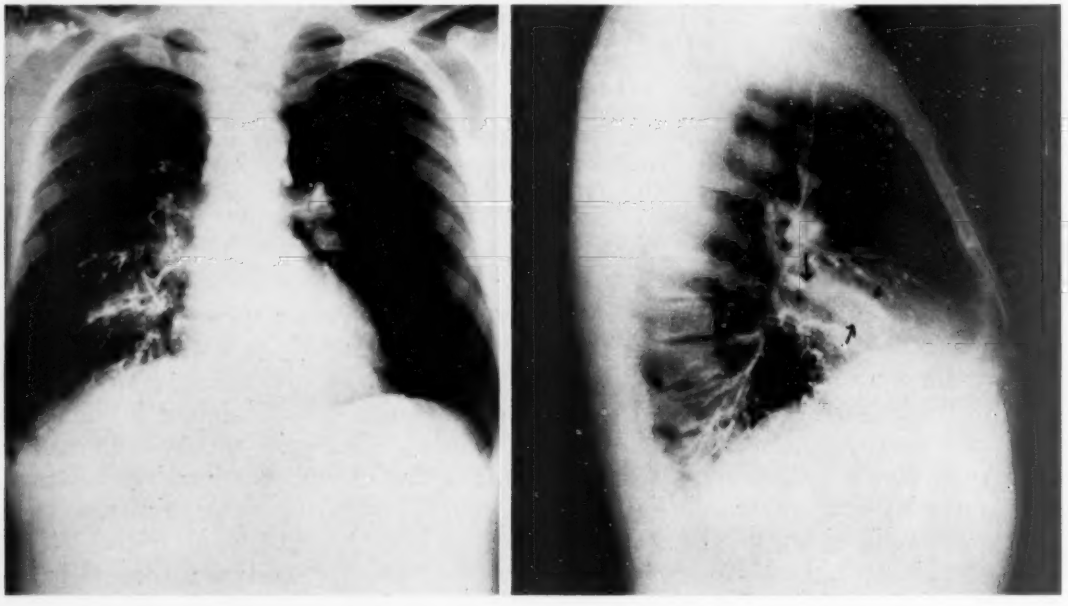


a *b*

FIG. 17, *a* and *b*. Collapse of the middle lobe with "tenting" of the diaphragm. The irregularity and unusual position of the shadow is attributed to pleural adhesions at the diaphragm. (Bronchoscopy and lipiodol injection revealed benign stricture of middle lobe bronchus thought to be due to tuberculosis.)

more dense than the medial portion. The diaphragm and costophrenic angle are clearly seen. The right border of the heart is partially obscured.

In Figure 15, *b*, lateral view, a triangular shadow with grossly irregular margins is demonstrated. The apex is just below the bifurcation of the trachea and the base



c *d*

FIG. 17, *c* and *d*. Same as above after lipiodol injection. No lipiodol enters the middle lobe.

obliterates the anterior costophrenic angle. The anterior lung tips of the upper and lower lobes are distinctly seen.

At operation the pleural cavity was found completely obliterated by adhesions and the middle lobe was therefore fixed at its peripheral surfaces. It was possible to separate the adhesions and remove the middle lobe alone. It had shrunken markedly in size and the usual changes of advanced bronchiectasis were found.

In the posteroanterior view (Fig. 16, *a*), a sharply demarcated, homogeneous, equilateral triangular shadow is seen with its angles placed at the lung root, at the fifth rib near the mid-axillary line, and at the anterior costophrenic angle respectively. The sides of the triangle are concave. The right cardiophrenic angle is obliterated but the right border of the heart is distinct. The anterior leaf of the right diaphragm is elevated and irregular. The heart is slightly displaced toward the right.

The lateral view (Fig. 16, *b*) is complicated by pleural disease at the anterior costophrenic angle of the left lung. A wedge-shaped shadow, however, is seen with its apex pointing posteriorly and upward. The base of the wedge is in contact with the anterior chest wall and measures approximately 7 cm. The base of the anterior aspect of the right upper lobe is outlined and extends from the second interspace anteriorly to the bifurcation of the trachea. The septum between the upper and lower lobes on the left side is distinctly seen in the original film.

In Figure 17, *a*, the right side of the diaphragm is slightly elevated and shows "tenting" at its mid-portion. There is an irregular linear and homogeneous area of dullness extending from the fourth rib in front to the diaphragm. The maximum density is along a line drawn from the bifurcation of the trachea to the middle of the diaphragm. The inferior margins of this area are relatively sharp, whereas the superior margin fades out gradually. There are calcified glands in the region of the right main bronchus and left lung root. The blood vessel shadows in the right lung are less numerous than those in the left, and there is apparent increased radiance in the region of the right upper lobe, the right costophrenic angle and the cardiophrenic angle due to compensatory changes. The heart is slightly displaced toward the right. The right border of the heart is distinct and right lung root is slightly depressed. Particular attention is directed to the increased radiance of the right cardiophrenic angle. The shadows crossing this area are blood vessels.

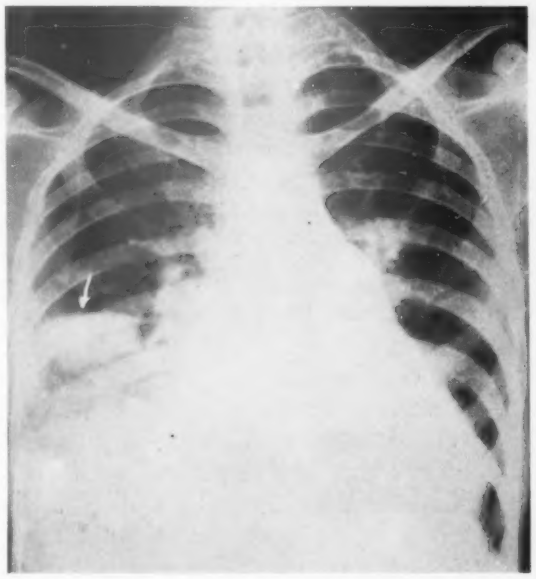


Fig. 18. The collapsed middle lobe is in a horizontal position. Necropsy showed the pleural space between the middle and upper lobes obliterated by adhesions. There were also adhesions of the parietal pleura anteriorly and posteriorly. The collapse of the lobe was apparently due to a large embolus secondary to rheumatic heart disease.

The lateral projection (Fig. 17, *b*) shows an ill-defined, slightly fusiform area of density, extending anteriorly and downward from the region of the bifurcation of the trachea to within 3 cm. of the diaphragm. The anterior inferior margin of this shadow is continuous with a white line which intersects the diaphragm at its highest point and what is commonly called "tenting" of the diaphragm is thus produced. There is some lipiodol in the lower lobe alveoli, and the superimposed calcified glands exaggerate the mediastinal shadow.

Figure 17, *c*, shows some distortion of the lower lobe bronchi and obstruction of the middle lobe bronchus.

In Figure 17, *d*, lipiodol demonstrates an obstruction of the middle lobe bronchus and a filling defect in the lung in the region of the shadow seen in Figure 17, *b*, is noted.

Although the presence of pleural adhesions near the lower limit of the inferior septum of the middle lobe has not been proved in this case it is thought that the characteristic tenting of the diaphragm and the position of the middle lobe are sufficient evidence to allow its presentation. Repeated bronchoscopic and lipiodol examinations definitely established the diagnosis of obstruction of the middle lobe bronchus. Several rather unsatisfactory biopsies are histologically chronic inflammation.

Figure 18 shows the characteristic findings of rheumatic heart disease with pulmonary edema and pleuritis. Situated just below the usual position of the superior septum of the middle lobe there is a shadow with a slightly convex superior margin and an irregular inferior margin. The medial margin is sharp and angular whereas the lateral margin fades out into the lateral chest wall. This shadow measures 6×3 cm. and was thought to be due to interlobar extension of pleural effusion, but necropsy revealed collapse of the middle lobe due to a large pulmonary embolus, secondary to rheumatic heart disease and associated with edema of the lung and pleural effusion on the right. The pleural effusion did not extend into the fissure between the upper and middle lobes. Instead, this space was found to be entirely obliterated by adhesions. There were also adhesions between the parietal and visceral pleura over the anterior and posterior aspects of the right lung. The position of the collapsed middle lobe is unusual and produces a confusing picture. The absence of a lateral view prevents further classification. It is thought, however, that the unusual position of the shadow produced by collapse of the middle lobe was caused by pleural adhesions.

SUMMARY

1. Accurate diagnosis of pulmonary disease depends upon exact localization of the disease process. Due to advances in thoracic surgery, it is becoming increasingly necessary for the roentgenologist to localize pulmonary disease to the lobe involved.

2. The normal size, shape and position of the middle lobe have been discussed.

3. Attention has been directed to the study of the right lateral teleroentgenogram of the chest, with particular attention to shadows cast by the right middle lobe. These shadows have been compared with the anatomical findings in a series of fifty-six proved cases.

4. Although a complete examination of the chest including roentgenoscopy and all views necessary should be done, information obtained from the standard right lateral teleroentgenogram is probably essential for accurate localization of disease, particularly in the middle lobe.

5. In the lateral projections of the chest, consolidation of the lateral aspect of the middle lobe casts a triangular shadow, whereas consolidation of the medial portion may cast a rectangular shadow. Consolidation may also produce convexities of the middle lobe septa simulating encapsulated fluid under pressure.

6. The fusiform and "overlapping" shadows commonly attributed to interlobar effusion have been discussed and emphasis has been placed upon the fact that shadows heretofore interpreted as interlobar effusions are more commonly due to disease within the middle lobe. Interlobar extensions of pleural fluid and thickening of interlobar septa are not uncommon, but primary encapsulated interlobar empyema in the region of the middle lobe is thought to be rare.

7. Visualization of normal pulmonary septa is common and thickening of the septa is thought to be due to pleural disease. Shadows simulating thickened interlobar pleura are often cast by disease in the middle lobe. The importance of displacement of visible interlobar septa in deter-

mining the degree of lobar collapse or destruction is emphasized. The obvious fact that shadows simulating interlobar disease must occupy the normal position of the septa has been noted.

8. The various disease processes in the middle lobe which have been erroneously interpreted as perihilar thickening, pleural pericardial disease, thickened interlobar septa, etc., are presented.

9. The size, shape and position of a contracted middle lobe is markedly influenced not only by surrounding disease but by pleural adhesions. Illustrative cases are presented.

10. Although certain suppurative diseases of the middle lobe can be accurately diagnosed by roentgen examination alone, the importance of bronchoscopic and lipiodol examinations before surgical procedures is obvious.

11. The secondary and compensatory changes in the thorax resulting from lobar collapse are of extreme importance in roentgen diagnosis, and some of these changes will be discussed more completely in a later paper.*

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* Photographs are by W. C. Lown, Massachusetts General Hospital.

SYNOVIAL MEMBRANES IN VARIOUS TYPES OF ARTHRITIS

A STUDY BY DIFFERENTIAL STAINS*

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THREE years ago one of us (Ghormley)[3] presented a brief review of the pathologic changes observed in a study of specimens of resected joints. In that review, the observations were based mainly on the bony and cartilaginous changes that one would expect to find in the type of material studied. At this time, it is our purpose to present some observations made in a study of a group of synovial membranes obtained from pathologic joints. This material comprises 63 specimens, most of which were whole synovial membranes. They were obtained in the course of synovectomy, and, as a rule, from the knee joint. There are also included a smaller number of specimens which were obtained for biopsy; these were obtained from various joints and from patients who had various types of involvement of the joints. In the majority of cases the pathologic condition was diagnosed proliferative arthritis (atrophic, infectious, rheumatoid), and it is from these cases that the most of the whole synovial membranes were obtained.

Before going any deeper into the pathology of these synovial changes it may be well to review some of the newer work on the anatomy and physiology of joints. An excellent review of the literature on the structure and function of the synovial membrane may be found in an article by Sigurdson. He demonstrated lymphatics and nerves in his own material, and concluded from his researches that the inner surface of the capsule of joints is not a distinct membrane. Thus, he would do away with the old established conception that there is a distinct synovial membrane which lines joints and which not only is present anatomically but is physiologically active and may secrete synovial fluid. Rynearson expressed the opinion that the synovial membrane is physiologically active and that it reacts specifically to various materials, and that the particulate substances are engulfed by the macrophages while fluid and colloid substances are transported through the blood and lymph channels. Kuhns, in an excellent article, described the lymphatic drainage of joints and noted that inflammation in synovial tissues may decrease the activity of the lymphatics, but with subsidence of this inflammation the lymphatics again function. Persistent inflammation in synovial tissue is dependent to a certain extent on the non-function of the lymphatics.

One of the most interesting and unusual studies on the synovial membrane is that of Vaubel, who studied the cells of the synovial membrane in tissue culture. He found that these cells divide both by direct division and by mitosis, that they are mesoblastic in origin, and as a rule revert to fibroblasts. He chose the name "synoviblast" because he felt that these cells elaborate a ground substance, as do chondroblasts or osteoblasts, and that this ground substance is the synovial fluid. He also noted the elaboration of enzymes, which may dissolve coagulated plasma, and regarded this as a physiologic function which may be observed in vivo, as there are many references in the literature to the fact that synovial fluid may dissolve bone. The same author further showed that actively growing synovial cells may produce mucin.

Thus, there is a wide divergence of

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

opinion. On the one hand, there are those who claim that there is no such thing as a distinct synovial membrane; while, on the other hand, there are those who claim that not only is there a synovial membrane but that it may be found to secrete a "ground substance" as well as enzymes and mucin. In spite of the long-established conception that normal synovial fluid is merely a transudate and has practically the same chemical constituents as does blood plasma, one is forced to the conclusion that there must be more than a simple transudation of material to form synovial fluid and that there are, somewhere in the synovial membrane, cells which have some secretory function and which produce the synovial fluid in all of its variations.

One of us (Ghormley) previously has stressed the importance of the changes in the synovial membrane in cases of proliferative arthritis.[1] Most of those who have studied pathologic material from joints realize that the most notable change in this type of arthritis is the change which occurs in the synovial membrane. The changes in the other structures of the joint are, of course, important and of the greatest significance, but the changes in the synovial membrane are more striking and more characteristic. Besides material from cases of proliferative arthritis, we have obtained material from cases of tuberculous arthritis, from degenerative and traumatic arthritis, from synovial osteochondromatosis, and from pyogenic and gonorrheal arthritis.

The importance of the roentgenologic changes in these conditions will be discussed very briefly. The most important changes to be noted are as follows: (1) A swelling of the soft tissues around the joint is often the only positive sign seen in the roentgenograms, in the early stages. (2) The presence of fluid in the joint may be detected in good roentgenograms by distention of the capsule. (3) Bony atrophy may be observed and should always be noted. Its presence or absence in many instances is an important point in the diagnosis. There are a good many cases in which post-traumatic painful atrophy may be an important and difficult problem from the standpoint of the clinician, and it should be diagnosed clinically and roentgenologically. (4) If other bony changes are present, the process usually has reached an advanced stage. Unfortunately, in many such cases the pathologic process is so far advanced when patients come to a clinician that the roentgenogram usually shows bony changes. In cases in which no bony changes are present, however, and diagnosis cannot be made by the roentgenologist, the clinician cannot avoid the responsibility of an accurate diagnosis with the statement that there is no trouble present, because of a normal roentgenogram.

The patient should receive the benefit of any doubt about the presence of a condition like arthritis. All of us have perhaps at times told the patient that no arthritis was present, on the basis of a normal roentgenogram, largely for the sake of the patient's morale. But the truth is that most patients who have arthritis are seen by some doctor before any diagnosis can be made roentgenologically. At this stage, the disease should be recognized clinically and treatment commenced. It is probably true that a good deal of improvement in the results could be obtained with recognition and institution of proper treatment before the disease has reached an advanced stage. It must be remembered that, in general, in any case in which the changes are so far advanced as to show bony changes in the roentgenogram, the pathologic condition is advanced and the prospects of curing such a lesion completely are minimal.

For this study we chose a method a little different from that commonly described in the works on pathologic changes in joints. The sections were cut as nearly identical as possible, and similar sections were stained (1) with hematoxylin and eosin which is the stain commonly used by all students of histopathology; (2) with Van Gieson's method, which is particularly suitable for staining connective tissue and for the differentiation of old connective tissue from new; (3) with the Mallory-Hei-

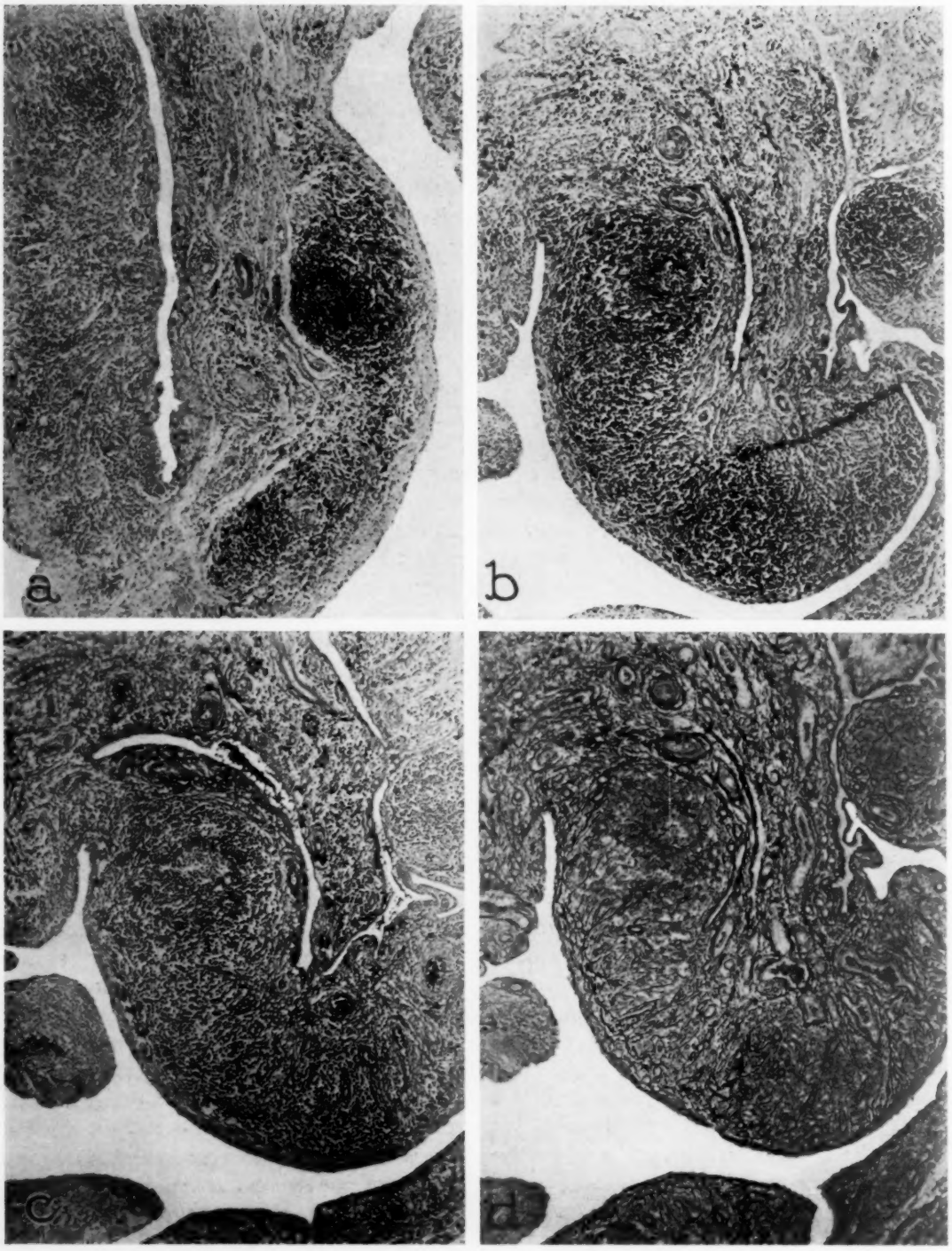

FIG. 1. Sections of synovial membrane showing proliferative arthritis: *a*, stained with hematoxylin and eosin; *b*, stained with Van Gieson's stain, *c*, stained with the Mallory-Heidenhain stain; *d*, stained with Perdreau's stain (×50). It may be noted that the focal collection of cells is not perivascular.

denhain stain, which likewise is particularly suitable for staining connective tissue and is more sensitive than the Van Gieson stain as it stains the young fibroblasts and young connective tissue, and (4) with Perdreau's stain, which is a silver stain that stains the stroma of the tissue, the walls of the blood vessels, but does not stain the cellular elements.

By such means it was felt that it might be possible to gain a little insight into the early fibrotic changes which take place in synovial membranes that are the site of an inflammatory process. It also was felt that it might be possible to determine the mooted question as to whether or not the focal collections of cells seen in synovial membranes, which were obtained from joints that were the site of proliferative arthritis, were perivascular infiltrations, as maintained by some authors, or whether they were some other form of histologic change more in the nature of a response to some abnormal stimulus.

PROLIFERATIVE ARTHRITIS

In studying these changes in synovial membranes obtained from cases of proliferative arthritis, one is impressed with the fact that the development of the focal collections seems to bear no relationship to the duration of the disease. That is to say, one may find typical focal collections in advanced proliferative arthritis as well as in early stages of the disease. No definite connection between the duration of symptoms and the stage of development of the focal collections could be found. The focal collections themselves may at times present various appearances. At times they are seen simply as collections of small round cells or lymphocytes but at other times they appear much more like a tubercle with epithelioid cells. Definite mitotic figures have been seen in these focal collections at times. A study of these tissues which have been stained with the Van Gieson and Mallory-Heidenhain stains shows that the underlying stroma is connective tissue but is very scarce in amount, and when they are stained with the Perdreau stain it is obvious that the focal collections are not perivascular collections of lymphocytes (Fig. 1). No blood vessels or only an occasional capillary may be seen in the region of the focal collection when the tissue is stained with the Perdreau stain. Varying degrees of thickening of the membrane may be observed. Vascular changes are not particularly characteristic. Edema, which may or may not be present, may vary in amount. The type of cell seen in the focal collection is principally the small round cell. Some larger cells may be observed, which probably are "monocytes." Whether or not these are all of the same origin cannot be said. The histologic picture of the synovial membrane, except for the focal collections, is not unusual. The gross changes and their distribution are more characteristic. Typical pannus formation takes place with subchondral invasion and ultimately destruction of the cartilage by this process of replacement. This seems to show that this is a specific reaction of these cells to an abnormal stimulus of some sort, probably chemical, and leaves much to be explained as to the actual underlying causes of the condition.

Much has been written regarding the etiology of infectious arthritis and the pathology has been described by some authors. Formerly, these collections of cells were not noticed and even now an occasional writer describes the pathologic changes seen in proliferative arthritis without any mention of this particular change, which, by all odds, is the most significant change seen in sections of synovial membrane from such joints. When the whole story of infectious or proliferative arthritis is told, it will probably be found that these changes are in the nature of an allergic response of the synovial membrane to some chemical poison, which may be a toxic by-product of infection, or some other abnormal substance which has collected in the joint.

DEGENERATIVE ARTHRITIS

In this type of arthritis, the changes in the synovial membrane are of little significance. In spite of a marked change in the

gross appearance of the synovial membranes, the microscopic appearance has few, if any, characteristic features. There is a thickening of the membrane with fibrosis and increased vascularity, but there is not a very marked thickening of the surface layer of cells. Perivascular infiltration is almost absent and focal collections of lymphocytes are wholly absent. More or less edema is usually present. One may see a considerable amount of fat in the deeper layers of these membranes at times.

TRAUMATIC ARTHRITIS

So far as the histologic picture is concerned, this condition is almost identical with degenerative arthritis. If one could examine all synovial membranes from traumatized joints, one would find a wide variety of appearances, all of which would represent different stages in the same sort of process. The essential changes are such as are seen in any tissue which is the site of a traumatism. Ultimately, fibrosis takes place, and this is the outstanding feature of the change in the synovial tissue. Whether or not one accepts the conception of a traumatic arthritis, the more one studies the pathologic changes in joints which are the site of repeated mild traumatisms or constant strains, as well as in those which are the site of a more severe trauma, the more one is impressed that a characteristic change takes place. We previously have described this change and repetition of this description is not necessary. Suffice it to say, the chief lesion is one of the articular cartilage; there is a gradual degeneration with early splitting of the matrix and subsequent fibrillation, which in some cases leads to complete destruction of the cartilages of the weight-bearing surfaces or of the cartilage covering those surfaces affected by the traumatism.

TUBERCULOUS ARTHRITIS

The tuberculosis seen in synovial membranes is, as a rule, an extensive thickening with fibrosis, and is characterized by the presence of multiple tubercles. It is not usual to see caseation in a synovial membrane. When this occurs it is usually the result of involvement of the adjacent bone by the tuberculous process. Varying degrees of thickening of the membrane are present, but, as a rule, there is much more thickening of the membrane than there is free fluid. One occasionally may find very little or no fluid in a tuberculous joint, when it is aspirated. Therefore, the presence of a great amount of fluid in a joint, if demonstrable in a roentgenogram, is evidence against, rather than for, tuberculosis.

We have pointed out before that the extension of the synovial membrane by pannus formation throughout non-pressure areas is not unlike that seen in proliferative arthritis. Too much significance should probably not be placed on this fact. It is true, however, and it some day may help to explain the etiology of proliferative arthritis.

The probable existence of "tuberculous rheumatism" is at times projected into the literature. This term does not signify an involvement of multiple joints by an active tuberculous process. Multiplicity of tuberculous lesions is a well-known fact, and is not to be considered in connection with a discussion of the so-called "rhumatisme tuberculeux" of Poncet. It should be noted that Poncet's diagnosis of tuberculous rheumatism was based on a family history of tuberculosis, or the presence of a true tuberculous arthritis which occurred either before or coincident with a polyarthritis. An excellent review of the entire subject is contained in an article by Brav and Hench. These authors reviewed about 650 cases of rheumatic fever, chronic atrophic polyarthritis, and 250 control cases, and were unable to demonstrate any higher incidence of familial tuberculosis or associated visceral tuberculosis in the cases of arthritis than in the control cases. The authors concluded that "no incontrovertible proof exists to support the existence of such an entity." Despite this, there is a persistent group of writers, particularly in Europe, who argue for such an entity, and who say

that, in some of these cases, *Mycobacterium tuberculosis* may be grown from the blood stream.

To date, no proof of the tuberculous etiology of chronic proliferative arthritis exists. It may be proved at a later date but this seems unlikely to us. From the standpoint of the roentgenologist, there is nothing to differentiate this condition from the usually recognized chronic proliferative arthritis.

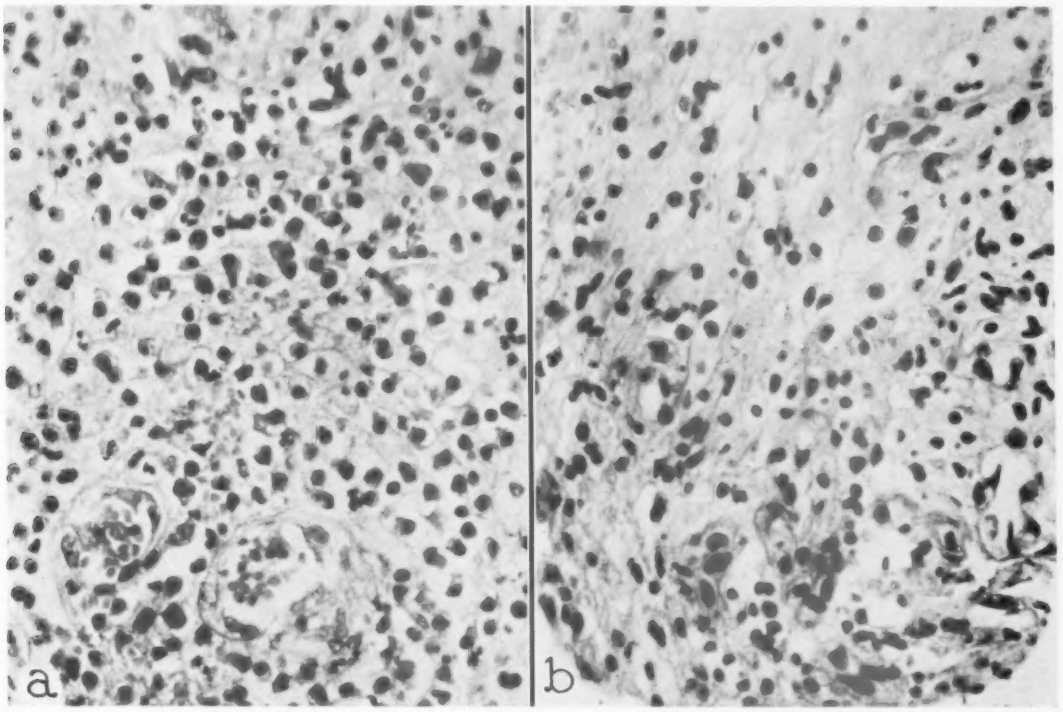

Fig. 2. Sections of synovial membrane showing suppurative arthritis: *a*, septic (staphylococcus) arthritis; *b*, gonorrheal arthritis (×365).

PYOGENIC ARTHRITIS

In this type of arthritis the pathologic picture changes constantly throughout the early stages of the disease. At first, a thickening of the synovial membrane with edema and the rapid infiltration of polymorphonuclear leukocytes takes place. As time goes on, a more advanced stage is reached, which is characterized by the production of fibroblasts and capillaries, and by the infiltration by plasma cells and polymorphonuclear leukocytes (Fig. 2). From this stage the condition may progress to the more advanced stages of fibrosis. As a matter of fact, in many of these joints in which the process has existed for some time, layers of various stages of inflammation may be observed in a cross section through the lining of the joint. The swelling and edema, which occur in this type of inflammation, produce secondary changes, notably those described by Kuhns, who found that the lymphatics are blocked in inflammatory lesions and restored to normal with subsidence of the signs of inflammation.

It makes little difference what member of the group of pyogenic organisms is present; the pathologic picture, so far as we have been able to observe, is essentially the same. While grossly there may be some difference in the reaction to the streptococcus and to the staphylococcus, under the microscope the appearance of the membrane is essentially the same. The same is true of the appearance of a membrane which is the site of a gonorrheal infection.

One rarely has the occasion to study such a membrane in the early stages of the disease. Later, fibrosis may be observed in the deeper layers of the membrane and successive stages of inflammatory reaction often can be observed. These stages, when analyzed, present the same type of histologic picture as is seen in other pyogenic membranes.

INTERMITTENT HYDRARTHROSIS

We have had occasion to study the synovial membrane from a case of intermittent hydrarthrosis. This condition has been recognized for years by those interested in arthritis. Its etiology today is almost as obscure as it was at the time it first was recognized. A peculiar pathologic or physiologic reaction of the lining of the joint, or of those elements of the joint which produce the synovial fluid, is about as accurate a statement of the etiology as one can give. In the sections of this lesion, which we have studied, a slight thickening of the lining layer of cells, without increased fibrosis or perivascular thickening, was all that could be seen. The periodicity, which at times is almost as accurately spaced as if it was timed by a clock, is the remarkable feature of this condition. Porter and Lonergan described the pathologic changes in a case of intermittent hydrarthrosis. They found more extensive changes in the synovial membrane than we did, but it should be noted that a severe generalized arthritis ultimately developed in their case and the probabilities are that the intermittent hydrarthrosis was a manifestation of this disease. This is a fairly common observation.

SYNOVIAL OSTEOCHONDROMATOSIS

This condition is rather rare but is just as interesting as any of the others. The condition usually manifests itself as multiple loose bodies in the joint, and is regarded by most of those who have studied the condition as a transformation of the synovial membrane into a benign tumor. We have seen malignant changes develop in one such case, and this may be considered to bear out, in a measure, the conception of a neoplastic metaphasia of the membrane as its etiology.[4]

SUMMARY

We have reviewed the pathologic changes seen in a series of synovial membranes removed from pathologic joints of various types. Sections of these membranes have been stained with four different types of stains, to bring out particularly the fibrous tissue background and the stroma. We have been able to show that the focal collections of cells seen in proliferative arthritis are not perivascular collections, as have been claimed by many, but represent a definite grouping of cells attracted by some stimulus similar to that seen in the formation of tubercles. Successive stages of inflammatory changes may be observed in proliferative arthritis as well as in pyogenic arthritis of various types.

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FASCIAGRAPHY

A PRELIMINARY REPORT

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WHILE recent advances in soft tissue roentgenography have increased our ability to study pathological conditions of the soft tissues, nevertheless, the use of a contrast medium within the tissues should have obvious advantages in greater definition of outline, increased contrast, and differentiation of soft tissue areas of the same density. It is felt that it would be of interest to give some of our preliminary results, particularly the technique, in order that others who are interested may explore the possibilities of this work.

In a recent communication[1] in this JOURNAL I outlined a fundamental concept of the architecture of the soft tissues in which they are compared to a series of cylinders, the outer ones being circumferential enclosing smaller distinct groups. The latter consist of muscles, vessels, and nerves. There are innumerable fascial spaces between the groups and within the muscles themselves, with a free intercommunication between the various spaces. Thus we have an ideal condition for the dissemination of a contrast medium throughout the tissues. The widespread dissemination of air in certain cases of lung puncture is interesting in this connection. According to Gratz[2] there is a mesothelial lining in these spaces. This is said to act in a similar fashion to the pleura permitting a gliding motion between muscle groups and being subject in certain cases to adhesions, in the same manner as adhesions form in the peritoneal or the pleural cavity. A solid contrast medium is not satisfactory owing to difficulty of diffusion, the possibility of setting up a foreign body reaction, and increased liability to infection. Air, therefore, is ideal. It has free diffusion, it can be readily injected, it is rapidly absorbed, and it does not predispose to infection.

Our preliminary experience would indicate that air injections with the resulting fasciagrams have interesting possibilities in the diagnosis of soft tissue tumors and certain types of inflammation of the muscles. They may have a valuable application in the diagnosis of nerve pain, particularly where there is a question of involvement of the larger nerves. In addition, it is an unequalled method for studying soft tissue anatomy with particular reference to the living anatomy and the study of the intercommunication of fascial planes.

While no untoward effect has been noted in the cases so far examined, there are two dangers which must be studiously avoided: infection and air embolus. Before starting an injection one should exclude diabetes and not attempt the procedure on very asthenic individuals. A differential white blood count is made and a relative or absolute polymorphoneucleosis is a contraindication. Any suspicion of a pyogenic infection, local or general, is an absolute contraindication, for obvious reasons. The patient should be specifically told what has been done. Otherwise a false diagnosis of gas gangrene may be made by others.

A 50 c.c. Luer syringe is used. A three way stopcock is connected to the syringe. The needle is attached to the opposite side of the stopcock, leaving the third way free and at right angles. For average work a needle with a special recessed flange base which permits of a firm grip is more satisfactory. The needle, a good size of which is No. 19 gauge by 3 inches, is introduced parallel with the long axis of the part under investigation at a slight angle with

[1] Carty, J. R. Soft tissue roentgenography. AM. J. ROENTGENOL. & RAD. THERAPY, April, 1936, *35*, 474.

[2] Gratz, C. M. Air injection of the fascial spaces. AM. J. ROENTGEOL. & RAD. THERAPY, June, 1936, *35*, 750.

FIG. 1. Injection of air into the soft tissues. Note the three way stopcock with valve between the syringe and needle. The index and middle fingers of the left hand lie within the recessed flange of the needle, serving to steady the latter during introduction and prevent wandering after the superficial fascia has been penetrated. Note that the needle runs parallel to the long axis of the part and at a slight angle with the skin.

the skin, after the usual sterile precaution.

The injection of a local anesthetic such as a cocaine derivative is contraindicated owing to the increased liability of infection and, moreover, is not required. Local freezing interferes with the entrance of the needle into the fascial space and also with the diffusion of air. When introducing the needle, firm pressure is used until the superficial fascia is penetrated. This is indicated by a slight "give." While it is possible to do a fasciagram by injecting the air into the subcutaneous space, nevertheless the procedure is apt to be quite painful and the diffusion of the air is not so complete. When the superficial fascia has been penetrated the valve is then turned so that there is a connection between the needle and the syringe. The plunger is then slowly withdrawn. Blood will appear in the syringe if a vessel has been entered. If this happens, the needle should be withdrawn entirely and a new start made, preferably not in the same area. If no blood appears, the valve is turned to the free way, then the plunger is withdrawn till 50 c.c. of air is in the syringe, then the valve is turned to connect with the needle and the injection done slowly. No filtering or special preparation of the air is necessary.

The amount of air which can be injected

FIG. 2. Fasiagram immediately after the injection of 90 c.c. of air. Note that most of the air is posterior but that there is some anterior to the humerus. Subsequent massage and manipulation of the arm resulted in a fairly even distribution of the air throughout the tissues.

varies according to the part involved, being more in the arm, for instance, where the potential spaces are larger and freer, than in the back. As much air, not to exceed 100 c.c., should be injected as the patient can stand. A roentgenogram is made immediately and the position of the air noted. If it is not uniformly diffused or if it is in the wrong locality there may be a general distribution by massage and further roentgenograms. In selecting the site of injection it is advisable, wherever possible, to avoid the neighborhood of large veins. The exact site in most instances is not a critical factor because of the ease with which the air can be distributed at will. Roentgenograms may be made at twelve and twenty-four hour intervals till the air is no longer in the tissues.

It is imperative that a soft tissue technique be used, as the average bone technique may obliterate the finer collection of air. The essential principle of such a technique is a high milliampere second and a low kilovolt (peak) ratio, as discussed in the previous communication. Occasionally there may be delayed pain reaction from twelve to twenty-four hours after injection which should not cause worry. Following injection the part swells, particularly in the case of extremities and, of course, typical crepitus is usually obtained. One usually sees immediately after injection in the normal individual a linear collection of air under the superficial fascia in the general neighborhood of the injection. Following massage and manipulation of the part, this localized collection is dissipated and there is a more general distribution. The whole tendency is for the air to assume a linear form without the formation of pockets. In the extremities muscle groups, particularly the superficial ones, may be displaced. However, where there is less motility of the soft parts such as in the back and lateral thigh this is not so marked. The air often extends along the great vascular trunk outlining the vessels in a striking manner. It is remarkable how far the air may extend. There is some evidence to suggest the possibility that lymphatics may play a part in this distribution. In some cases of myositis it has been noted that this linear distribution has been lost and the air apparently tends to form localized pockets.

SUMMARY

The diagnostic possibilities of the use of air as a contrast medium in the soft tissues as suggested by Gratz are discussed. The technique is given and the appearance of the fasciagram in a normal individual is briefly described.

AIR INJECTION OF THE FASCIAL SPACES*

A NEW METHOD OF SOFT TISSUE ROENTGENOGRAPHY

Preliminary Report

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SOFT TISSUE roentgenography has been thoroughly reviewed and partially standardized by Carty and others and has made rapid advances in the last few years. An improvement in roentgenographic methods may aid in the accuracy of diagnosis of pathological conditions involving the soft tissues. Actual visualization of the fascial spaces is possible if a safe contrast medium is used. For reasons stated later, air seemed to be the medium of choice.

FIG. 1. Roentgenogram of the neck of a patient with torticollis in which the fascial spaces of the left side have been injected with air. Note how muscle groups are outlined, also the moderate scoliosis of the cervical vertebra.

The surgical necessity of an accurate knowledge of the fascial spaces of the hand was well known by Kanavel and also a technique devised for studying them. The fascial spaces, in his preliminary work, were injected with plaster-of-Paris and red lead. Prentiss and Milgram injected the fascial spaces of the thigh with air for anatomical studies. The Chinese are said to have used air injections thousands of years ago. While the work of Kanavel and Milgram was particularly applied to the fascial planes in relation to infection, our researches were based on the desire to study these spaces as possible causes of pain of obscure etiology.

The anatomy and histology of the fascial spaces were studied and it was found that when specimens were injected with air, dissection was made much easier and we are able to photograph the dissection accurately. It is of interest to review pre-

FIG. 2. Roentgenogram of the lower lumbar and gluteal region following distribution of air in the fascial planes of the lumbar region and the thigh. Note the longitudinal streaks of air and even distribution of the same.

* Department of Surgery, Orthopedic Division, Columbia University, New York. Presented before the Annual Meeting of the Society of Plastic and Reconstructive Surgery in Atlantic City, June 14, 1935, and at the New York Academy of Medicine before the Section of Orthopedic Surgery and the Philadelphia Orthopedic Club, November 15, 1935.

vious work done to evaluate, if possible, any dangers which may be associated with the clinical use of this technique.

Cordier, in 1902, reported the therapeutic use of gaseous injections, and in a personal communication Bennett of Johns Hopkins informed me that he had used the injection of air in certain cases with definite therapeutic results. It has also been used successfully for many years as a contrast medium in joints and also in the study of the central nervous system. In the series of cases so far done we have used it exclusively on chronic cases and have had as yet no complications except varying degrees of discomfort for twenty-four to forty-eight hours after its use.

The fascial planes function as joints between various muscles and groups of muscles and enclose air tight spaces lined with mesothelium. Nerves traverse these spaces. In the same way as infection has has been known to settle in the joints between bones, these joints between muscles might be similarly involved. Fascial adhesions, by interfering with the mechanism of the soft tissues may account for the limitation of motion so frequently observed in rheumatic cases. Hence the reaction of the patients after this therapy was studied most carefully. In many of the chronic cases marked relief of symptoms followed the treatment and though the first cases were only done in April, 1935, and the series of cases is as yet too small to draw any definite conclusions, the freeing of the adhesions may be of definite therapeutic value.

The roentgenograms herewith presented are self explanatory. Adhesions of the fascial spaces are apparently shown roentgenographically by irregularities in the distribution of the air. The visualization of the spaces with the proper roentgenographic technique is not difficult. There may an increased permeability in the fascial spaces of the rheumatic.

In conclusion, a note of caution should be sounded as to the difficulties in injecting these potential spaces and the possible danger of embolism and infection following injection. Throughout it has been done in the operating room and the patients have been kept in the hospital for twenty-four to forty-eight hours. This procedure should never be used in cases that have not been thoroughly studied and never in cases having any infection. The roentgenograms are technically known as pneumofasciagrams.

Fig. 3. Roentgenogram of right lower lumbar and gluteal region of a patient with moderate rheumatism and marked sciatica. Note irregular distribution of the air in contrast to the linear distribution shown in Figure 2.

The author desires to express his gratitude to Doctors William H. Meyer, Ralph E. Herendeen and George Joseph Plehn who most kindly aided in the development of this technique. Particular thanks are due to Dr. John R. Carty who was associated with the author in the preparation of this preliminary report and whose article in this Journal of April, 1936, is much more complete than the above preliminary report.

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THE PRACTICAL VALUE OF ROENTGENOGRAPHY OF THE EPIPHYSES IN THE DIAGNOSIS OF PRE-ADULT ENDOCRINE DISORDERS*

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THE time and sequence of appearance of the centers of ossification of the normal human skeleton had received due attention from anatomists prior to the discovery of the roentgen ray. Their conclusions regarding normal standards were reasonably accurate when one considers the relatively limited material, the difficulty of obtaining the bodies of young individuals for anatomical dissection, the laborious method of investigation, the lack of clinical control and the darkness surrounding the subjects of biochemistry and endocrinology in that era. The roentgen ray provided a much less tedious and more accurate means of investigating the growth phenomena of large numbers of healthy living subjects and these advantages were soon appreciated. Roentgenologists have since displayed a healthy interest in the subject, but while they have accomplished much in the direction of establishing the normal time of appearance and union of the epiphyses, there has been a noticeable lack of interest in the significance of departures from normal standards. The anatomical point of view has apparently been inherited by the roentgenologists who carried on the work and the importance of the abnormal has been somewhat obscured in the intensity of the search for the normal. With the maturity of endocrinology as a science, the practical value of roentgenography of the epiphyses has become apparent, and this method of investigation has proved the means of recognition of previously unsuspected endocrinopathies, and thus led to the ultimate rehabilitation of a large group of individuals otherwise doomed to be classed with the unfortunates of humanity. An impression of the size of this group may be gained from the studies of Marinus and Kimball[17] who, in a survey of Detroit school children, found some form of endocrine imbalance in 18.6 per cent of those included in the study. Shelton[26] found an osseous retardation of two years or more in 15 per cent of 560 unselected children in the Santa Barbara County public schools. Unfortunately the information available on the value of roentgenography in this field has been poorly disseminated. To a very large number of physicians the practical value of roentgenography of the epiphyses is virtually unknown. In a few limited circles, on the other hand, the importance of the procedure is probably over-emphasized. The accumulation of roentgenological data applicable to the subject and an analysis of their true significance therefore seem a worthwhile project.

SOURCE OF MATERIAL

The impressions and conclusions offered in this report are based on a series of over 3,000 individuals upon whom more or less complete epiphyseal studies were made. Most of these patients consulted Dr. E. Kost Shelton or the late Dr. William Engelbach either because the patient himself or some friend or relative felt that an endocrine investigation was warranted. The incidence of endocrinopathies in this group is therefore considerably higher than in a corresponding number of general medical patients. For the most part, the abnormal cases have been thoroughly investigated both from clinical and laboratory standpoints. Moreover, the treatment has been directed with more than ordinary intelligence in that "shot-gun" prescribing was avoided and a determined effort was directed toward precise diagnosis and

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

treatment so that worthwhile conclusions could be drawn from the clinical results. While a statistical analysis of the material at hand would be of interest, the present study is more concerned with the actual value and limitations of roentgenography in a study of the epiphyses.

FIELD OF APPLICATION OF ROENTGENOGRAPHY OF THE EPIPHYSES AND COMPARISON WITH OTHER METHODS OF DIAGNOSIS

Since endocrinology is essentially concerned with a study of biochemical processes, and since biochemical imbalances are frequently reflected in an individual's metabolism, one of the first steps in the examination of a suspected endocrine disorder is to determine the individual's rate of metabolism. In the adult this is readily and satisfactorily accomplished by the respiratory method.* In the growing stage of life, metabolic disorders, if continued over a prolonged period, may cause a variety of changes in skeletal growth and development so that in the pre-adult age group two methods of investigating the metabolic status of a patient are available: the respiratory method and roentgen examination of the epiphyses. Since the application of roentgenography as a diagnostic procedure is restricted to the latter age group, the relative merits of the two methods will be briefly compared.

Availability and Expense. Talbot,[29] who has carefully studied the metabolism of children, is of the opinion that no device having a nose or mouth clamp is accurate until after the age of twelve years and that previous to that age the closed chamber method is necessary. The latter is a relatively expensive, exacting procedure and is available in only a few research centers. Roentgen examination of the epiphyses, on the other hand, requires only the simplest of roentgen apparatus and is therefore not only less expensive but is readily available to practically every physician. From the age of twelve until adult life is reached the two methods are about equally available and involve about the same expense to the patient.

Sources of Technical Error. While modern apparatus for the determination of basal metabolism has been highly perfected and most of the sources of mechanical error minimized, the personal factor admits rather wide variations, as demonstrated by successive tests on the same individual. The difficulty of obtaining the complete physical and mental composure essential to an accurate reading is exaggerated in the pre-adult group where anxiety and lack of poise are disturbing factors. As a result, it is frequently necessary to make repeated tests before any reliable conclusions can be arrived at. In infants and small children a further difficulty is encountered in that it is necessary to feed the child to prevent crying, and the result, even though technically accurate, does not represent basal conditions. Roentgenography of the epiphyses has a great advantage in this respect in that even reasonably good technique practically excludes the possibility of error in demonstrating the appearance or union of the various centers.

Sources of Error in Interpretation. Metabolism during the actively growing period of life is much less stable than after cessation of growth. Normal skeletal growth, instead of progressing at a fixed rate, consists of a series of spurts and stops and, while these variations follow the same general plan in all normal persons, it is frequently difficult to decide whether an individual is in a period of slow or rapid growth at any given time. Exhaustive studies on the dynamics of growth show a direct relation between *basal metabolism* and *rate of growth.* The most active period of growth is from birth through infancy and the minimum gain is immediately after the period of infancy. This explains the failure to gain and loss of appetite during the latter interval. Growth is again accelerated at the onset of puberty and continues until adult life is reached.

* Metabolic determinations based on cardiac output are as yet not dependable enough to be of practical importance.

Talbot has published a chart showing normal standards of metabolism for children of different ages but admits that "metabolism during puberty will have to be studied further before any standards may be accepted." Topper and Mulier,[30] after studying the metabolism of 38 children between the ages of ten and sixteen years, found a sharp rise in girls at the age of twelve to thirteen years and in boys at thirteen to fourteen years. There was no uniformity in the height or duration of the increase, and the accelerated metabolism was coincident with physiologic rather than chronologic age. Göttche,[12] Bedale[4] and Janet[15] arrived at similar conclusions. Furthermore, it is a well-recognized fact that even under the most accurate conditions the normal variation in metabolism is from −10 per cent to +10 per cent. In the pre-adult age group the normal variation is probably even more than this.

In point of accuracy, therefore, basal metabolism studies in the pre-adult age group leave much to be desired. Even if one disregards the possibility of technical error, the lack of dependability of so-called normal standards and the difficulty of determining whether the rate of growth (and therefore metabolism rate) is in a period of rest or acceleration at any given time make the interpretation of results rather uncertain and admit a very appreciable source of error.

The possibilities of error in the interpretation of roentgenographic studies of the epiphyses will be dealt with at some length in another part of this report. It must be admitted there is a substantial *normal* variation in the time and sequence of appearance and union of the various ossification centers, and that the magnitude of this variation increases *materially* after the onset of pubescence.

Other Points of Comparison. Roentgenography is less time consuming and more convenient from the patient's standpoint than basal metabolism tests. Moreover it provides a permanent, accurate and graphic record for comparison with subsequent studies. In acute endocrinopathies of recent onset, basal metabolism studies are far more informative than roentgenograms of the epiphyses for it is more than likely that such disturbances would not have time to seriously influence somatic development. For the same reason roentgen examination of the epiphyses has a distinct advantage over metabolic studies in chronic disorders because it affords a summary of the individual's endocrine history since birth and is not affected by temporary metabolic upsets.

To summarize briefly, we may say that roentgenography of the epiphyses is generally more informative than metabolic studies from birth until the onset of pubescence, after which the relative values of the two procedures become more equal. Neither method can entirely supplant the other. Metabolic studies have a marked advantage in acute endocrine disorders while roentgen examination of the epiphyses is more dependable in chronic disturbances.

NORMAL STANDARDS OF OSSEOUS DEVELOPMENT

Before discussing the significance of variations from the normal, it is necessary to consider some points regarding normal standards of osseous development. As previously stated, the literature in this respect is profuse. Allen,[1] Cohn,[8] Baetjer and Waters,[3] Camp and Cilley,[7] Pryor,[21] Hodges,[14] Davies and Parsons,[9] Paterson[19] and Flecker[11] are among the roentgenologists and anatomists who have published their observations regarding the normal time of appearance and union of the osseous centers. The clinicians Engelbach and McMahon,[10] and later Shelton,[25,27] not only published what they considered normal standards, but accumulated a great deal of evidence bearing on the meaning of departures from normal. Pryor's work was particularly important because he first drew attention to the fact, now generally conceded, that the somatic development of

the female for a given age is advanced over that of the male. Ruckensteiner[24] recently published a monograph treating exhaustively of normal osseous development and dealing briefly with the importance of certain variations from the normal.

Comparison of the results of the above authors reveals a rather great disparity of opinion in regard to the age at which the osseous centers normally appear and fuse, and at first glance lead one to conclude that the variation between the upper and lower limits of normal must be very large indeed. However, a more deliberate analysis of the material brings to light several points which explain the discrepancy:

(1) Data based on anatomical evidence indicate an earlier age for appearance of centers than those based on roentgen evidence. Anatomists contend they are able to demonstrate new centers before sufficient calcification has occurred to cast a shadow on the roentgenogram. This is apparently true. At any rate the point may be stipulated without reducing the value of roentgenography so long as *roentgen* studies are compared with *roentgen* standards of normal.

(2) Part of the disagreement is undoubtedly due to conclusions based on insufficient material and inclusion of subclinical endocrinopathies among the so-called normals.

(3) There has been some confusion in specifying the age at which appearance and fusion occur. For example, one author states that the pisiform appears at the age of eleven; another, that it appears during the twelfth year of life. Both mean the same yet they are likely to be construed differently. Likewise, insufficient care has been exercised in eliciting the exact age of the individuals included in some of the groups studied. A child will frequently give his age as eleven until the day of his twelfth birthday. This may result in an error of almost a full year in the final calculation.

(4) In many instances the influence of sex, race, climate and heredity have been entirely ignored or their importance underestimated. As previously stated, Pryor was first to recognize the fact that the skeletal development of girls was in advance of boys of the same age. In general, the colored races mature before the Caucasian and those living in hot climates before those in cold. The rôle of hereditary tendencies in influencing growth must be investigated in each individual case. It is a commonplace observation to note advanced development, bordering on precocity, in all the children of a given family, while in another the same processes are all uniformly delayed. The possibility of underlying endocrine pathology in many such instances is open to doubt.

Elimination of the above sources of error would considerably reduce the disparity of opinion in published reports. Until more conclusive data are at hand regarding the exact amount of normal variation one must adopt arbitrary standards. In our own practice we regard the following as normal limits for the ages mentioned:

Birth–1 year	3 months
1 year–3 years	6 months
3 years–6 years	9 months
6 years–12 years	1 year
12 years–20 years	2 years

It is important that the roentgenologist report any variation from the normal schedule, no matter how small. The clinician may then decide, after weighing the factors of race, climate, hereditary tendencies, general health and nutrition, etc., whether the variation is of significance.

PRACTICAL USE OF ROENTGENOGRAPHY OF THE EPIPHYSES

In the average patient it is obviously impossible for economic reasons and at the same time unnecessary to study the entire skeleton in order to form a reasonably accurate conclusion regarding the status of osseous development. As a matter of fact, it will frequently be found that more comprehensive studies are apt to lead to confusion because of the not unusual

occurrence of paradoxical development. For example, the distal epiphysis of the ulna should appear almost two years before the apophysis of the os calcis, yet occasionally the latter appears first. Such occurrences are frequently seen when the entire skeleton is studied, and a certain amount of confusion results. The question arises as to what regions should be studied to obtain a reasonably accurate conclusion. An analysis of established data shows that for a given age certain regions are critical, i.e., they show the appearance or fusion of a nucleus which normally occurs at that age. As a result, it is now our practice to examine only two areas in the routine cases and in the great majority of instances this proves to be sufficient.

Through the cooperation of Dr. E. Kost Shelton, whose clinical observations have served as an invaluable control measure, we have adopted the data given in Table 1 as a guide in practical roentgenography of the epiphyses. This table is based on findings accumulated largely through the investigations of Shelton, Flecker and Hodges. While the ages indicated for appearance and union of the centers are undoubtedly open to argument in some instances, the table is submitted simply as an indication of the critical regions to be examined for the various ages and as a convenient reference for the roentgenologist in interpreting results.

Attempts to use a single chart and formulate a simple rule for application to the two sexes have met with poor success. Separate data are therefore given for boys and girls. In order to obviate any possible confusion in indicating the age factor, we have used 10–11, 11–12, etc., to indicate the intervals between the tenth and eleventh birthdays, eleventh and twelfth birthdays, etc. It is strongly advised that in eliciting the age of the patient one obtain the exact date of birth so that the proximity of the next birthday is known, thus eliminating an appreciable source of error.

It will be noted that a study of the wrists and hands is included at all ages. This region includes a greater number of ossification centers than any other one area and the time and sequence of appearance of these centers are distributed over a relatively large number of years. Consequently it is not only of value in establishing the original diagnosis but serves as a convenient region to check the progress of a case after institution of treatment. When wide departures from normal occur, the hand and wrist film serves as an index in determining the extent of the departure and is informative in deciding what supplementary studies are necessary to form an accurate opinion of the state of osseous development.

The demonstration of metacarpal pseudo-epiphyses is another reason for employing the hand and wrist study routinely. Epiphyses normally occur on the proximal end of the first and on the distal ends of the second, third, fourth and fifth metacarpals. When epiphyseal nuclei are seen on the distal end of the first or on the proximal ends of the second, third, fourth or fifth metacarpals they are usually spoken of as accessory epiphyses or pseudo-epiphyses. We have for some time been aware that these pseudo-epiphyses are commonly seen in known cases of delayed skeletal development. Upon investigating we found that Köhler[16] had noted this fact some twenty years ago. His explanation of the matter is quite interesting:

> The failure of the proximal epiphyseal nuclei of the metacarpals in man and other mammals is explained osteogenetically, that a proximal epiphyseal nucleus is always present in the primitive formation, but that the epiphyseal line is reached by the ossifying diaphysis before it gets time to attain to an independent formation. In retarded ossification, as is found in the fins of marine mammals, the proximal long nucleus gets time to form because the ossification process from the diaphysis goes forward very slowly indeed. Analogous conditions can be expected in man in diseases in which the ossification of the skeleton is delayed, and that is really the case. . . . Thus pseudo-epiphyses would be regarded in general as an endocrine stigma. Their appearance indicates an endocrine retardation of the skeletal growth.

Table I

	Boys		Girls	
Age	Part Examined	Normal Findings	Part Examined	Normal Findings
At birth	Knee (Lat) Ankle (Lat)	Dist. femur, prox. tibia Calcaneus, talus	Knee (Lat) Ankle (Lat)	Dist. femur, prox. tibia Calcaneus, talus and cuboid
Birth to 1 year	Hand and wrist (Pa) Ankle (Lat)	*Hamate, capitate* Calcaneus, talus, *cuboid, 3rd cuneiform, dist. tibia*	Hand and wrist (Pa) Ankle (Lat)	*Hamate, capitate, dist. radius* Calcaneus, talus, cuboid, *3rd cuneiform, dist. tibia, dist. fibula*
1–2 years	Hand and wrist (Pa) Elbow (Ap)	Hamate, capitate, *distal radius* *Capitellum*	Hand and wrist (Pa) Ankle (Lat)	Hamate, capitate, dist. radius, *prox. phalanges* Calcaneus, talus, cuboid, 3rd cuneiform, *1st and 2nd cuneiforms, scaphoid* dist. tibia, dist. fibula
2–3 years	Hand and wrist (PA) Ankle (Lat)	Hamate, capitate, dist. radius, *prox. phalanges* Calcaneus, talus, 1st cuneiform, *3rd cuneiform*, cuboid, *phalanges* and *metatarsals*, dist. tibia, *dist. fibula*	Hand and wrist (PA) Ankle (Lat)	Hamate, capitate, *triquetrum*, dist. radius, *metacarpals and middle and distal phalanges* Calcaneus, talus, cuboid, *scaphoid*, 1, 2, 3, cuneiforms, dist. tibia, dist. fibula, *phalanges* and *metatarsals*
3–4 years	Hand and wrist (Pa) Ankle (Lat)	Hamate, capitate, *triquetrum*, dist. radius, *phalanges* and *metacarpals* Calcaneus, talus, 1st and 3rd cuneiforms, *2nd cuneiform*, cuboid, *scaphoid*, dist. tibia, dist. fibula, phalanges and metatarsals	Hand and wrist (Pa) Knee (Lat)	Hamate, capitate, triquetrum, *lunate*, dist. radius, metacarpals and phalanges *Patella*, dist. femur, prox. tibia, *prox. fibula*
4–5 years	Hand and wrist (Pa) Elbow (Ap)	Hamate, capitate, triquetrum, *lunate*, dist. radius, metacarpals and phalanges Capitellum, *prox. radius*	Hand and wrist (Pa) Elbow (Ap)	Hamate, capitate, triquetrum, lunate, *navicular*, dist. radius, metacarpals and phalanges Capitellum, *prox. radius*
5–6 years	Hand and wrist (Pa) Knee (Lat)	Hamate, capitate, triquetrum, luminate, *navicular, gr. multangular*, metacarpals and phalanges Dist. femur, prox. tibia, *prox. fibula, patella*	Hand and wrist (Pa) Elbow (Ap)	Hamate, capitate, triquetrum, luminate, navicular, *gr. multangular*, metacarpals and phalanges, dist. radius, *dist. ulna* Capitellum, prox. radius, *med. epicondyle*
6–7 years	Hand and wrist (Pa) Elbow (Ap)	Hamate, capitate, triquetrum, luminate, navicular, gr. multangular, *less. multangular*, dist. radius, *dist. ulna* Capitellum, prox. radius, *med. epicondyle*	Hand and wrist (Pa) Elbow (Ap)	Hamate, capitate, triquetrum, luminate, navicular, gr. multangular, *less. multangular*, dist. radius, dist. ulna Capitellum, prox. radius, med. epicondyle

TABLE I—(*Continued*)

	Boys		Girls	
Age	Part Examined	Normal Findings	Part Examined	Normal Findings
7–8 years	Hand and wrist (Pa) Pelvis (Ap)	Same centers as at 6–7 years Union: *Ischium and pubes*	Hand and wrist (Pa) Pelvis (Ap)	Same centers as at 6–7 years Union: *Ischium and pubes*
8–9 years	Hand and wrist (Pa) Ankle (Lat)	Same centers as at 6–7 years Dist. tibia, dist. fibula, tarsals, metatarsals and phalanges, *apophysis of calcaneus*	Hand and wrist (Pa) Elbow (Lat)	Same centers as at 6–7 years Capitellum, prox. radius, *prox. ulna*, med. epicondyle
9–10 years	Hand and wrist (Pa) Elbow (Lat)	Same centers as at 6–7 years Capitellum, prox. radius, *prox. ulna*, med. epicondyle	Hand and wrist (Pa) Elbow (Ap and Lat)	Same centers as at 6–7 years Capitellum, prox. radius, med. epicondyle, prox. ulna, *trochlea*
10–11 years	Hand and wrist (Pa) Elbow (Ap and Lat)	Same as at 6–7 years Capitellum, prox. radius, prox. ulna, med. epicondyle, *trochlea*	Hand and wrist (Pa) Elbow (Ap and Lat)	Hamate, capitate, cuneiform, lunate, gr. multangular, less. multangular, *pisiform*, dist. radius and dist. ulna Same centers as 9–10 years
11–12 years	Hand and wrist (Pa) Knee (Lat)	Hamate, capitate, triquetrum, luminate, navicular, gr. multangular, less. multangular, dist. ulna, dist. radius, *pisiform* Dist. femur, prox. tibia, prox. fibula, patella, *tibial tubercle*	Hand and wrist (Pa) Elbow (Ap)	All centers present Capitellum, prox. radius, prox. ulna, med. epicondyle, trochlea, *lat. epicondyle*
12–13 years	Hand and wrist (Pa) Elbow (Ap)	All centers present Capitellum, medial epicondyle, trochlea, *lateral epicondyle*, prox. radius, prox. ulna	Hand and wrist (Pa) Elbow (Ap)	All centers present Capitellum, med. epicondyle, trochlea lat. epicondyle, prox. radius, prox. ulna. Union: *capitellum to trochlea and lateral epicondyle*
13–14 years	Hand and wrist (Pa) Elbow (Ap)	All centers present All centers present. Union: *capitellum to trochlea and lateral epicondyle*	Hand and wrist (Pa) Elbow (Ap and Lat)	All centers present All centers present. Union: capitellum to trochlea and lateral epicondyle and *prox. ulna*
14–15 years	Hand and wrist (Pa) Foot (Lat)	All centers present Dist. tibia, dist. fibula, metatarsals, tarsals and phalanges, *epiphysis for base 5th metatarsal*	Hand and wrist (pA) Elbow (Ap and Lat)	All centers present. Union: *terminal phalanges* All centers present. Union: *lower conjoint epiphysis of humerus, prox. ulna*

Table I—(*Continued*)

Age	Boys		Girls	
	Part Examined	Normal Findings	Part Examined	Normal Findings
15–16 years	Hand and wrist (Pa) Pelvis (Ap)	All centers present. Union: *distal phalanges* Union: ilium, ischium and pubis	Hand and wrist (Pa) Elbow (Ap)	All centers present. Union: *phalanges and metacarpals* All centers present. Union: lower conjoint of humerus, *med. epicondyle*, *prox. ulna*, *prox. radius*
16–17 years	Hand and wrist (Pa) Elbow (Ap)	All centers present. Union: *distal phalanges* Union: *lower conjoint epiphysis of humerus*, *med. epicondyle*, *prox. radius*, *prox. ulna*	Hand and wrist (Pa) Ankle (Ap)	All centers present. Union: *metacarpals and phalanges* All centers present. Union: *Dist. tibia*, *dist. fibula*
17–18 years	Hand and wrist (Pa) Ankle (Ap)	All centers present. Union: *metacarpals and phalanges* All centers present. Union: *dist. tibia and dist. fibula*	Hand and wrist (Pa) Shoulder (Ap)	All centers present. Union: metacarpals and phalanges, *dist. ulna* All centers present. Union: *acromion* and prox. humerus
18–19 years	Hand and wrist (Pa) Knee (Ap)	All centers present. Union: metacarpals, phalanges, *dist. ulna* All centers present. Union: *prox. tibia*	Hand and wrist (Pa) Knee (Ap)	All centers present. Union: metacarpals, phalanges, dist. ulna, *dist. radius* All centers present. Union: prox. tibia, *prox. fibula* and *dist. femur*
19–20 years	Hand and wrist (Pa) Knee (Ap)	All centers present. Union: metacarpals, phalanges, dist. ulna and *dist. radius* All centers present. Union: prox. tibia, *prox. fibula*, *dist. femur*	Hand and wrist (Pa) Pelvis (Ap)	All centers present. Union complete All centers present. Union: *iliac crests*
20–21 years	Hand and wrist (Pa) Pelvis (Ap)	All centers present and united All centers present. Union: *iliac crests*	Hand and wrist (Pa) Shoulder (Ap)	All centers present and united All centers present. Union: prox. femur, acromion, *clavicle*

The above table indicates the critical examinations and normal findings for the various ages. When a new center appears or unites at a given age the fact is indicated by italics.

I cannot subscribe to the last statement because pseudo-epiphyses are commonly seen in supposedly non-endocrine conditions due to defective germinal protoplasm and, further, because they are occasionally encountered in perfectly healthy individuals. Nevertheless, pseudo-epiphyses may be considered a fairly reliable indication of delayed ossification and their presence is particularly significant in those borderline cases approaching the lower limit of normal development.

A word of caution should be given regarding the roentgenographic technique in studying the wrists of patients between the ages of nine and thirteen years. The center for the pisiform is often situated at such a point that, in the conventional postero-anterior projection, it is obscured by the superimposed cuneiform and can be easily

overlooked. This difficulty may be overcome by simply tilting the direction of the central ray about 20° caudad. If the pisiform is present it will be clearly shown in the resulting film.

While the table indicates a definite age for the appearance of the individual carpal centers, the sequence of appearance of these nuclei is not always the same. Os magnum, unciform, cuneiform and pisiform are quite dependable and appear with great uniformity at the ages indicated. The semilunar, scaphoid, trapezium and trapezoid are less constant in their order of appearance. The statement that the sequence of appearance of the latter group is a family characteristic lacks proof.

The second region studied in each case is chosen because of the information it offers at the particular age indicated. In most instances one or more centers are scheduled to appear or fuse under normal circumstances. Any appearance or fusion new to the age is printed in italics. In general it will be found that the films of the latter region give a more precise indication of the osseous age of the patient, and in combination with the hand and wrist study usually afford adequate information for diagnostic purposes.

SIGNIFICANCE OF ABNORMAL OSSEOUS DEVELOPMENT

The close interrelation of the glands making up the endocrine system makes discussion of the individual units a difficult matter. Purely uniglandular disturbances rarely, if ever, occur, since a disturbance of one upsets the equilibrium of the other members to a greater or lesser extent.

Before discussing the endocrinopathies affecting skeletal growth and development, it seems convenient to first review the rôle of the individual glands of the endocrine group as they affect these processes under normal conditions. Although this matter has been the object of much intelligent study and experiment in recent years many points remain controversial. Without attempting to weigh the arguments pro and con, the following considerations are offered not as established facts but simply as working principles which will aid in understanding the departures from normal development incident to disorders of endocrine function.

Thyroid. The thyroid has little or no primary action on the rate of bone growth but exerts a profound influence on differentiation of bone tissue. B. M. Allen[2] noted that if the anlage of the thyroid was removed in the tadpole growth continued for some time at a normal rate but metamorphosis did not occur. In the human a deficiency of thyroid produces an analogous result: growth may proceed for a time but tissue differentiation is delayed and the osseous nuclei are late in appearing.

Pituitary. Of the many hormones said to be elaborated in the pituitary we are chiefly concerned with but three in this study:

(1) *Growth hormone* which is probably elaborated by the acidophilic cells of the anterior lobe and plays a major rôle in controlling the rate of bone growth. There is abundant experimental proof to demonstrate the presence and effect of this principle. Hypophysectomy in young animals results in dwarfism. Growth hormone extracted by several observers increases the growth increment in young pituitary dwarfs. Theoretically then a pure excess of growth hormone would result in normal appearance of the osseous centers, rapid growth, particularly of the long bones and normal epiphyseal closure time.

(2) *Thryotropic principle.* The exact cellular origin of this hormone has not been established but it is recovered from the alkaline fraction of the anterior lobe. It is closely allied to the growth hormone and serves as a connecting link between pituitary and thyroid. Pure excess or deficiency would theoretically have the same effect on skeletal development of hyperthyroidism and hypothyroidism respectively.

(3) *Gonadotropic principle* is probably elaborated by the basophilic cells of the anterior lobe and serves as a connecting link between pituitary and gonad. While

it probably has no direct action on skeletal development it has an important secondary effect through its influence on development and function of the gonads.

Gonads. The effect of the gonads on skeletal development is said to be due to the elaboration of sex hormone, a product of the interstitial cells. No one fully understands the exact mechanism controlling epiphyseal closure, but there is reason to believe the gonads are deeply concerned in the process. In case of sexual precocity the epiphyses unite long before the normal time. Conversely, if gonadal function is impaired or lost during childhood or adolescence, the epiphyses remain open and growth continues beyond the normal time. However, the pituitary-gonad-thyroid interrelation introduces many ramifications of thought relating to epiphyseal closure, and a diversity of opinion exists. Until further evidence is offered it will simplify matters to regard epiphyseal closure as predominantly a function of sex hormone.

Adrenal. The adrenal, like the pituitary and gonads, has its embryonic origin in the wolffian body and is closely related to the pituitary (adrenotropic principle of the pituitary) and also to the gonads. Adrenal cortex tumors result in the same clinical picture as basophilic adenomas of the pituitary (Cushing's syndrome) and certain tumors of gonadal origin. In the absence of tumor, the effect of the adrenal, if any, on skeletal growth remains unknown.

Thymus. The classical experiments of Rowntree, Clark and Hanson[23] on the injection of thymic extract into mice showed a marked acceleration of growth and early maturity in the offspring if the injections were continued through several generations. The practical application of this work in humans has not been determined. Engelbach and McMahon observed retarded osseous development in a few infants with enlarged thymus but admitted the point had not been satisfactorily investigated. I have noted no uniform skeletal changes associated with thymus enlargement.

Parathyroid. Parathyroid hormone appears to have no direct effect on bone growth and development other than its influence on fixation and mobilization of calcium. It is conceivable that an overactivity may result in *apparent* osseous retardation due to insufficient calcification in newly differentiated nuclei.

Pancreas. Morrison and Bogan,[18] after studying the skeletal development of 68 diabetic children, concluded that bone age was usually advanced over chronological age in pre-diabetic children and in those in whom the onset of the disease was recent. When diabetes had been present for three years or more osseous development was retarded. Gray and Geyman[13] arrived at similar conclusions. The possibility of the pancreas exerting any direct influence on skeletal development, however, is open to grave doubt, and it seems probable that the effects described are due to secondary imbalances of the thyroid or pituitary.

Pineal. The function of this small gland remains veiled in mystery. The fact that certain pineal tumors have been associated with early sexual maturity has led some investigators to conclude that it is closely related to the pituitary-gonad mechanism. In view of the lack of definite information, the pineal may be ignored in the present discussion.

In summary then, the important hormones influencing skeletal growth and development are: thyroid hormone, through its control of tissue differentiation; growth hormone, by its influence on the rate of bone growth; and sex hormone because it plays an important rôle in closing epiphyses. Two other hormones, the thyrotropic and gonadotropic principles of the pituitary, are important because of the part they play in coordinating the pituitary-thyroid-gonad mechanism. With these precepts in mind we may proceed to a consideration of the endocrine imbalances affecting the dynamics of skeletal growth and attempt to correlate the same with the roentgenographic findings in the epiphyses.

Infantile and Juvenile Hypothyroidism and Myxedema. Hypothyroidism is by far the most common endocrinopathy in the pre-adult age group. This is indeed a fortunate circumstance because, owing to the chronic character of the disorder, even relatively mild deficiencies are easily recognizable through roentgen examination of the epiphyses and because the response of this condition to substitution therapy is generally highly satisfactory and often spectacular.

Advanced juvenile myxedema and cretinism are not commonly seen in this country, but the number of children exhibiting thyroid deficiencies of a degree not sufficient to produce the typical textbook picture or even leading clinical symptoms is much larger than might be expected. The symptoms may consist merely of behaviorisms such as inability to get on with companions, shyness, backwardness in school, lack of interest in the usual games and diversions common to the individual's age. In more advanced cases sleepiness, langor, mental sluggishness and loss of appetite may be the only complaints. To watch the mental and physical improvement in such children after proper treatment is one of the really gratifying experiences of practicing medicine. The following summary is typical.

CASE I. W. F., a boy, aged ten years and six months, was brought in for an endocrine investigation. His parents state that the boy is irritable, difficult to control and flies into a rage on the slightest pretext. He does fairly well in school but has few companions and prefers to come home immediately after school and sleep or read. He is considerably smaller than other boys of his age.

Family History. The patient's mother was born and lived for many years in Switzerland. For a major portion of her life she was afflicted with severe attacks of asthma. The condition was refractory to all treatment until 1927 when daily small doses of thyroid were instituted. She has been absolutely free from attacks since that time.

Physical Examination. The patient is a male child under stature for his age (51.3 inches) with a peculiar dull expression in the eyes and face. He answers questions slowly and avoids direct gaze. He stands with a marked lordosis and has a moderate girdle adiposity. The physical examination is otherwise negative.

Laboratory Findings. The blood and urine examination are normal. The basal metabolism is −20 per cent.

Roentgen Examination. The osseous development is approximately five years retarded (Fig. 1).

Diagnosis. Hypothyroidism (severe congenital).

Clinical Course. The patient was under observation for thirty months. He was given thyroid by mouth daily. There was no other treatment. His general improvement was remarkable. The behaviorisms completely disdisappeared and he grew 8 inches during the period of observation, at the end of which time his general health was excellent and he appeared normal in every way.

While prolonged thyroid deficiency always results in retarded epiphyseal age, the converse is not necessarily true. Delayed appearance of centers may be due to what, for lack of a better term, is described as defective germinal protoplasm. Osteochondrodystrophy, osteopsathyrosis, mongolism and some other supposedly congenital or hereditary conditions are included in this category. Incidentally Rowntree, Clark and Hanson's work on thymic extract in mice has encouraged the view, long maintained by some, that certain conditions now regarded as due to defective germinal protoplasm will eventually be recognized as low-grade endocrine disturbances continued through several generations (consider Case II).

The roentgenologic differentiation between retardation due to thyroid deficiency and that resulting from defective germinal protoplasm is not easy and a test of therapy is frequently required to decide the issue. When the protoplasm is at fault the centers are likely to be imperfectly formed and poorly calcified. The anatomical landmarks are obscure and fragmentation of the epiphyses is a common occurrence. There is frequently a noticeable

departure from the normal *sequence* of appearance of the centers. Telford-Smith phalanges (shortened middle phalanx fifth finger) are present in most instances. Not uncommonly a mild thyroid deficiency is partly responsible for the osseous retardation in this type of case and a certain amount of improvement may follow a regimen of thyroid by mouth. Even a slight improvement in these unfortunate children is highly appreciated by the parents. One should be extremely cautious in prognosis, however, even though a thyroid deficiency exists.

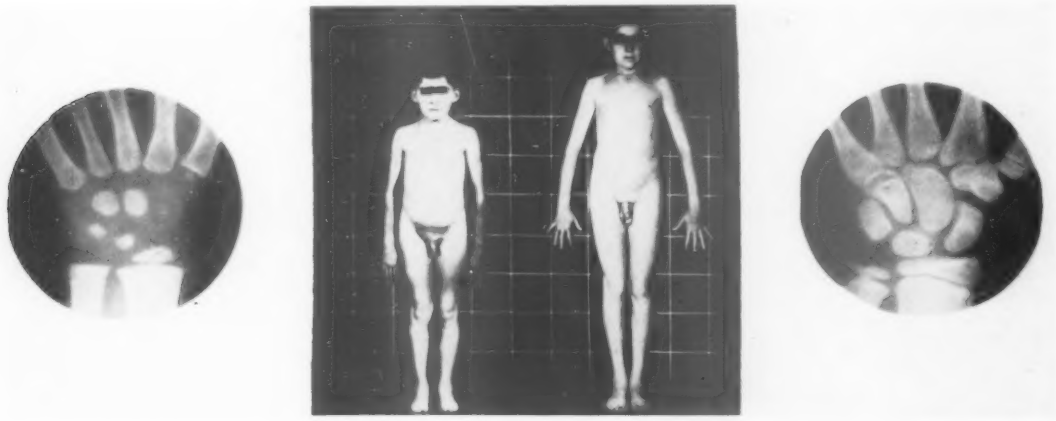


Fig. 1. Case 1. Hypothyroidism before treatment (*left*) at ten years six months of age. Note the marked delay in osseous development. The bone age is about four years. *Right*, the same case after two and a half years of thyroid substitution. The osseous age is ten years.

Another possible point of differentiation between retardation of hypothyroid origin and that resulting from defective protoplasm lies in the analysis of creatine metabolism. In 1911 Rose[22] pointed out that creatinuria was physiologic in children of both sexes previous to the onset of adolescence. Beumer and Iseke[6] noted that in children with hypothyroidism there was always a diminution or complete suppression of creatine secretion. Their work has recently been verified by Poncher, Visscher and Woodward.[20] Although the point has not been investigated, there would presumably be no change in creatine metabolism in those instances of retardation where the protoplasm is at fault. The following case illustrates the difficulties in diagnosis that may be encountered:

Case II. J. O., a boy aged five years three months, complained of restlessness at night and lack of energy during the day. At birth his fontanelles were observed to be very large but no other abnormality was noted. His physical and mental development have apparently been normal to date. His diet has always been adequate. There have been no serious illnesses.

Family History. The only suggestive point in the family history is the fact that his mother's half brother has an unusually large head.

Physical Examination. The patient is a fairly well-developed, well-nourished and mentally alert child. His head is large and his eyes are widely spaced. Hs is moderately knock-kneed and has a rather marked lumbar lordosis. The clavicles appear to be rudimentary.

Laboratory Findings. Plasma phosphates, serum calcium and phosphorus and blood sugar determinations were normal. The blood and urine were negative. The blood Wassermann was negative. The basal metabolism was normal.

Roentgen Examination. Studies of the skull and shoulders show the open fontanelles, widely separated sutures and rudimentary clavicles characteristic of cleido-cranio-dysostosis. The joint spaces appear widened throughout the body and the articulating epiphyses are irregular and have eburnated margins. In general

there was a marked delay in the appearance of the centers of ossification. Some of the findings were paradoxical, however. For instance the patella was present, which suggested an osseous age of five years but the wrist and hand were that of a two year old child. The os magnum

FIG. 2. Case II. Hand and wrist illustrating the type of retardation due to defective germinal protoplasm. Only two carpal centers are present and they are ill-formed and poorly calcified. Note the Telford-Smith phalanx (middle phalanx little finger), and the pseudo-epiphyses at the proximal ends of the second and fifth metacarpals.

and unciform were the only carpal centers present and they were ill developed and poorly calcified. Telford-Smith phalanges were present and there were well-formed pseudo-epiphyses on the second and fifth metacarpals (Fig. 2).

Clinical Course. The child was given an iron tonic and thyroid extract by mouth. The latter was poorly tolerated at first but continued administration over the past three months has resulted in noticeable clinical improvement. Sufficient time has not elapsed to permit conclusions based on epiphyseal changes.

The problem in the above case was to decide whether the osseous retardation was due to hypothyroidism or defective protoplasm. The child exhibited none of the signs of juvenile hypothyroidism and the lack of uniformity of the osseous delay, the poorly calcified centers and the presence of Telford-Smith phalanges suggest that the germinal protoplasm was at fault. However, the poor tolerance of thyroid by mouth (frequently encountered in thyroid deficiency) and the clinical improvement following its continued use suggest that a thyroid factor may be involved in the osseous delay. Repeated observations will be necessary to decide the point.

Caution is urged in rendering an opinion of osseous retardation between birth and the age of one year. During this interval the ratio $\frac{\text{Normal variation time}}{\text{Age of patient}}$ is so large that the value of roentgen examination of the epiphyses is definitely limited. A child of a hypothyroid mother is occasionally referred for roentgen examination of the epiphyses to determine the integrity of thyroid function. Even if there is an apparent retardation a diagnosis of hypothyroidism is hazardous. In this country thyroid deficiency is rarely recognized in the first year of life.

Moreover, a diagnosis of hypothyroidism should not be ventured on the basis of *delayed closure* of epiphyses because the rôle of the thyroid in closure of the epiphyses is probably not important. It is true that the epiphyses usually do close late in myxedema but this is probably due to secondary deficiency of the gonadotropic principle of the pituitary. In the absence of pituitary involvement, hypothyroids may exhibit early maturity and premature closure of the epiphyses. This fact, together with the frequent occurrence of cessation of menstruation and loss of libido in *hyper*thyroidism has given rise to

the conception of an antagonistic action between the thyroid and gonads.

Hyperthyroidism is not common before puberty. When it does occur it runs an acute course and the time interval is too short to permit serious disturbances of skeletal development. If continued over a long time one would expect premature appearance of the centers but not enough instances have been observed to establish the truth of this hypothesis.

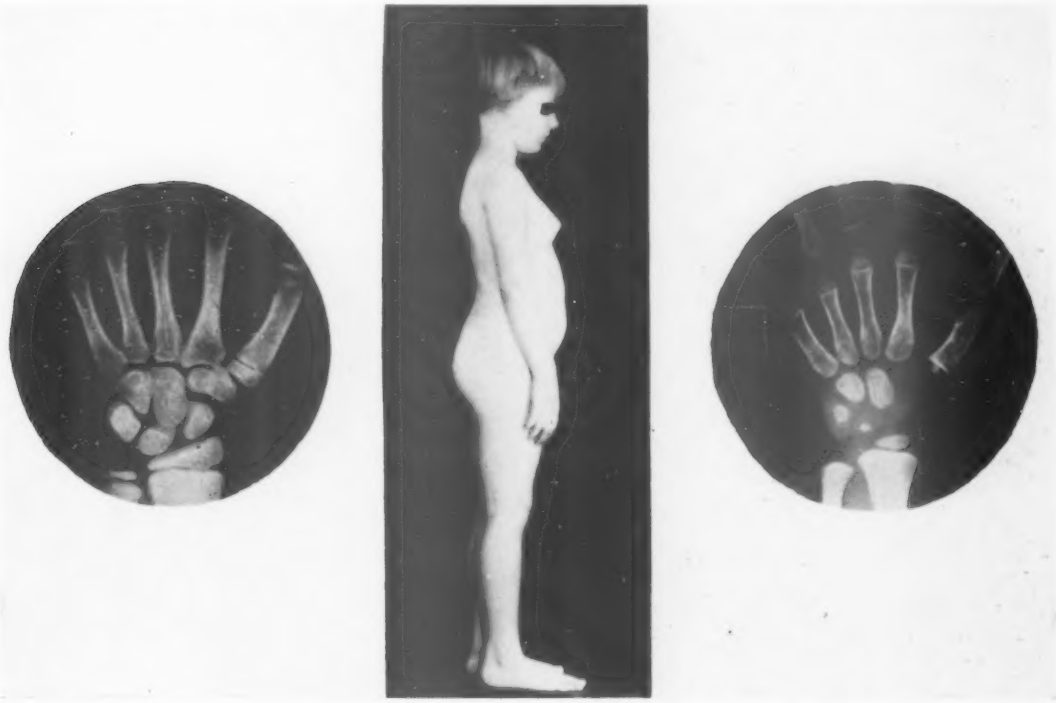


Fig. 3. Case III. Macrogenitosomia age four years one month. The child has menstruated regularly since the age of four months. The normal carpal development for the age is indicated on the right and the carpal development of the patient on the left. Note the advanced growth and differentiation in osseous development (Bennett's case).

Hypergonadism is a relatively rare endocrine disturbance characterized by sexual precocity and rapid growth until the onset of pubescence, after which growth of the long bones soon ceases. It may be primary or secondary to hyperpituitarism. The characteristic roentgen findings are early appearance of the centers (probably sympathetic thyroid overactivity), rapid bone growth (excessive growth hormone due to pituitary overactivity) and early closure of epiphyses (excess of sex hormone). These children are larger and stronger than normals of the same age but when pubescence occurs and their epiphyses close they soon lose their advantage. This explains the unusually large genital development occasionally observed in men of short stature. Hypergonadism is frequently associated with tumors of the pituitary, adrenals or gonads. The following case has been reported in detail by Bennett[5] and the roentgen findings are typical:

Case III. L. Y., a girl, aged four years one month, complained of painful breasts toward the end of the menstrual cycle. Menstruation began at the age of four months and had occurred regularly every twenty-eight days since that time. Growth has been very rapid since birth. The child is unusually active at play but about once a day she suddenly lies down and goes to sleep immediately. After about two hours sound sleep she awakes refreshed and is

Fig. 4. Case IV. Gigantism. The patient is twenty-one years ten months of age and 84 inches in height. The excessive stature is due to excessive growth hormone. There was no evidence of pituitary neoplasm. Note that there is no delay in epiphyseal closure.

as active as ever. She is strongly attracted to men.

Physical Examination. The patient is a robust child the size of an eight year old. She has the breast development of a girl of fourteen years. No tumor masses are palpable. The other findings are unimportant.

Roentgen Examination. There was a uniformly advanced osseous development throughout the body. The centers were unusually large for the age and there was beginning union of the phalangeal epiphyses (Fig. 3).

Gigantism. Excessive adult stature may result from one of two conditions: (1) *excessive rate* of growth over the normal period of skeletal growth, or (2) *normal rate* of growth over an abnormally long period of time.

In the first instance there is an excess of growth hormone. This excess may exist throughout the growing stage of life and result in the so-called true giant. In such cases the hyperpituitarism is confined to the acidophilic elements. The centers appear at the normal time, grow rapidly and close at the normal age.

Excessive growth hormone may be due to pituitary neoplasms of the acidophilic type in which case the accelerated skeletal growth is limited to the active phase of the

Fig. 5. Case V. Over-stature of the eunuchoid type. Growth progresses at the normal rate but continues over a longer than normal period of time due to delayed closure of the epiphyses (deficient sex hormone). The patient is twenty-three years six months of age and still growing. Note the marked delay in epiphyseal closure.

neoplasm. If epiphyseal closure precedes the active phase acromegaly results.

The following case, encountered in a routine examination of high school boys, illustrates the roentgen findings in gigantism due to relatively pure growth hormone excess.

Case iv. J. C., a boy, aged twenty-one years and ten months, has no complaints other than excessive height. He is 84 inches tall. Growth has been rapid since birth and he has always been much taller than other boys his age. His mother and father, two sisters and one brother are all of normal stature. There is no history of endocrine disturbances in the family. Genital development is normal.

Roentgen Findings. The sella turcica is normal in size and contour. There is no evidence of a destructive process. There is no unusual calcification in the vicinity of the pituitary fossa. The epiphyseal age is twenty-one years. There is no evidence of delayed union. The epiphyses are well formed. The metacarpals and phalanges are excessively long (Fig. 4).

In the second class of gigantism, growth hormone is present in the normal amount but growth continues over an unusually long period of time due to delayed epiphyseal closure. The latter is the result of deficient sex hormone and results in the eunuchoid giant. The condition may be primary, due to gonad deficiency or of pituitary origin. The roentgen findings are normal appearance time of the centers, normal rate of growth, delayed closure time. The following case, while not actually in the giant class, illustrates the overgrowth associated with hypogonadism.

Case v. B. B., female, aged twenty-three years and six months, complains of never having menstruated. She was an apparently normal, full term baby. Childhood infections included pertussis, measles and mumps. There were no complications or sequelae. At the age of fifteen she was told she had tuberculosis and was under treatment for a year, after which all symptoms disappeared.

Family History. There was a history of migraine and goiter in the family. Her mother and grandmother both had large goiters.

Physical Examination. The patient is a young female of moderately asthenic type and above average stature (5 feet 10 inches). She has grown an inch during the past year. Pubic hair is very sparse. The breasts are flat. Her configuration is definitely eunuchoid (Fig. 6).

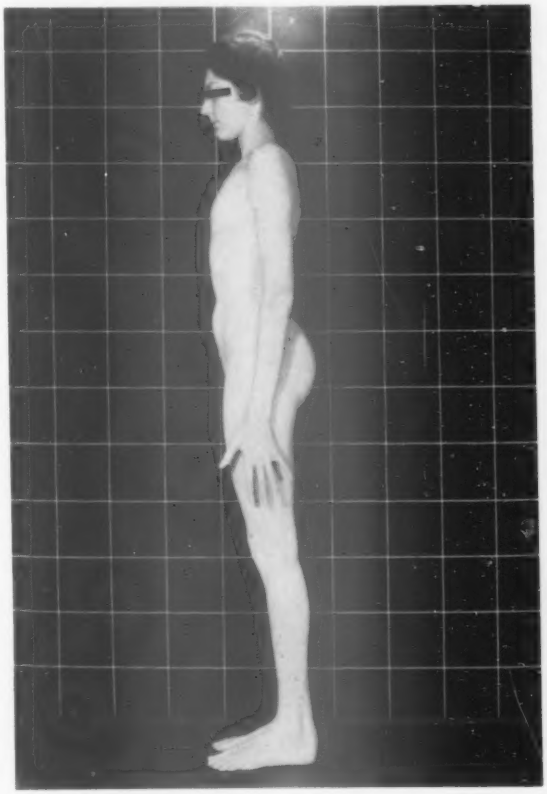


Fig. 6. Case v. Note the eunuchoid configuration.

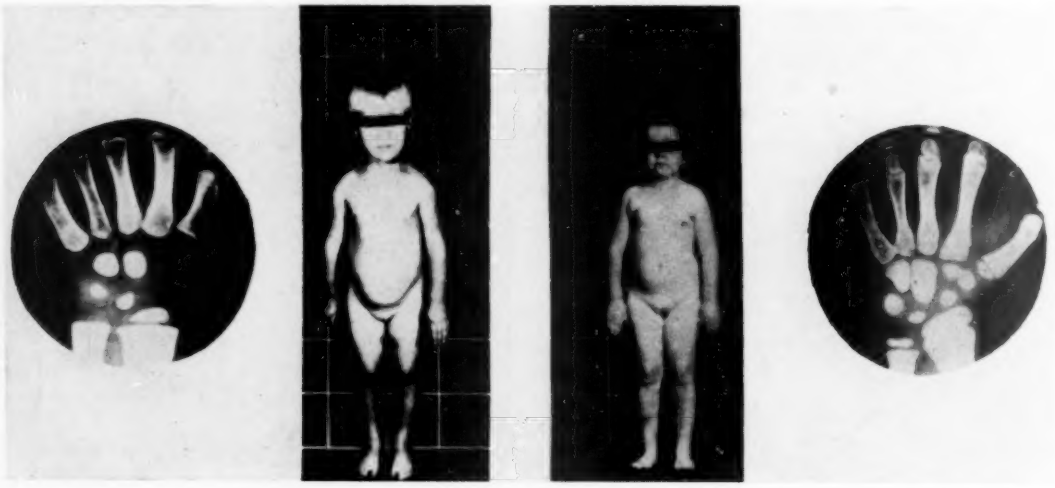
Laboratory Findings. The blood and urine are negative. Sugar tolerance was within normal limits. Basal metabolism on several occasions varied between −10 and −18 per cent.

Roentgen Examination. The epiphyses of the long bones are partially open. The metacarpals and phalanges are long and slender and their epiphyses are incompletely closed. Retarded epiphyseal union is the outstanding roentgen finding (Fig. 5).

The important point in the above case is the fact that this patient is still growing, although almost twenty-four years of age. Apparently growth will continue until epiphyseal union is complete.

Dwarfism. Of the many types of dwarfism, roentgen examination of the epiphyses is of value chiefly in two, hypothyroidism

and hypopituitarism. In the former, the primary pathology is a deficiency or total lack of thyroid hormone. The pituitary is usually involved to some extent and the adult stature depends on the degree of pituitary deficiency. If marked, the cretinic dwarf obtains; if slight, the hypothyroid may attain normal size. The characteristic roentgen finding is delayed appearance of the centers (retarded differentiation due to lack of thyroid). Growth of the centers is delayed due to associated pituitary involvement (growth hormone deficiency) and closure of the epiphyses occurs late in life (gonadotropic and sex hormone deficiency). The following case, previously reported by Shelton, illustrates the roentgen findings.



CASE VI CASE VII

FIG. 7. Comparison of hypothyroid dwarfs aged eight years three months (Case VI) with hypopituitary dwarf aged nine years eight months (Case VII). Note the marked osseous retardation in the former. In the latter the number of centers present is approximately normal.

CASE VI. J. S., a girl, aged eight years three months, complained of understature, painful joints and constipation. Four years ago a diagnosis of rickets was made and since that time she has taken large quantities of cod-liver oil without apparent improvement. She was a normally developed, full term baby and was not suspected of being undersize until two years of age. Her diet has been adequate and well balanced. There was no history of endocrine disturbances in the family.

Physical Examination. The patient is a poorly developed child with a marked disproportion between the length of the legs and the length of the torso. She is 40.8 inches tall (10 inches below normal for that age). Her responses are slow and she is mentally sluggish. Her skin is dry and the hair is scanty.

Laboratory Examination. The blood and urine are normal. Basal metabolism studies were not attempted.

Roentgen Examination. There is a uniform delay in appearance and growth of the osseous centers. The bone age is four years (approximately four years retarded) (see Fig. 7).

Pituitary dwarfism is primarily due to a deficiency of the hormones of the anterior lobe of the hypophysis. The roentgen findings are characteristic and readily differentiated from those of hypothyroid dwarfism. The centers appear at the normal time but growth is greatly retarded due to growth hormone deficiency. Compare the wrist of the pituitary dwarf (Fig. 7) with that of the hypothyroid of approximately the same age. A thyroid factor is usually present but may not be outstanding. If the growth hormone deficiency is relatively pure, sexual development may be complete and the epiphyses unite at the scheduled

time. However there is usually a concomitant deficiency of the gonadotropic fraction and a common finding is delayed or incomplete sexual maturity and delayed closure of the sutures. The following case has also been reported by Shelton, Cavanaugh and Evans.[28] The roentgen findings are typical.

Case vii. J. M., a girl, aged nine years eight months, complained of retarded growth. She was 35.2 inches in height, approximately 17 inches below normal for that age. Dwarfism was first suspected at the age of three. She has been unusually healthy in every other way. Her mother and father were of normal stature.

Physical Examination. The patient is a markedly undersized child with an infantile configuration, wizened expression and thin scanty hair. She has a moderate genu valgum and an accentuated lumbar lordosis.

Laboratory Findings. The blood and urine were normal. The basal metabolism was normal. Sugar tolerance was moderately high.

Roentgen Examination. The outstanding roentgen finding is the small size of the centers. The osseous nuclei are rounded, poorly developed and highly calcified. In some instances they appear laminated. There is no remarkable delay in appearance of the centers (see Fig.7).

Progress. The patient was under observation for twenty-five months during which time an alkaline extract of the bovine anterior hypophysis was injected intragluteally five days a week. She grew 5.4 inches during the period of observation. The estimated increment for the same period based on the average growth for the previous four years was 2.29 inches.

SUMMARY

There are two possible ways of investigating the metabolism of individuals in the pre-adult age group: the respiratory method and roentgen examination of the epiphyses. From the age of one year until the onset of puberty roentgen examination has a definite advantage in availability, economy and accuracy. From the onset of adolescence until adult life is reached basal metabolic studies are more informative in acute endocrinopathies while roentgen examination is of more value in chronic endocrine disorders. The practical use of roentgen examination of the epiphyses is discussed and the possible sources of error described.

The hormones chiefly concerned in the control of osseous development and growth are: thyroid hormone, sex hormone, growth hormone and the gonadotropic and thyrotropic fractions of the anterior lobe of the hypophysis. Prolonged disturbances in the elaboration of these hormones result in recognizable disturbances of epiphyseal growth and development.

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DISCUSSION

DR. P. C. HODGES, Chicago. There is only one phase of this paper about which I am able to speak with some slight degree of confidence, that is the part that deals with the appearance of the epiphyses in the growing normal subject. Even here, I have not said that I could speak with authority, simply that it is a matter to which I have devoted some thought and in which I have a good deal of interest.

It is true, as Dr. Clark has told you, that one faces a confusion of uncertainty when he turns to the literature for a verbal picture upon which he can build a mental image of the changes that the skeleton undergoes during childhood. The chart which I published some time ago and to which Dr. Clark has kindly referred, represents no original work of my own, but was merely my attempt to clarify my own mental picture of the published observations of others. As far as I am concerned, the chart has served one purpose, namely, it has enabled me to discover that much of the material coming through my hands daily in connection with the roentgen work for our pediatric service does not conform very well to the chart.

Dr. T. Wingate Todd of Western Reserve University, is quite convinced, he tells me, that there is no such thing as individual variation in the time relationships of human epiphyseal growth. This idea, of course, runs counter to most of the other literature but Dr. Todd is a splendid anatomist and has been studying this particular program for many years. I understand that only restriction of funds in the Brush Foundation, under which Dr. Todd works, has prevented the appearance of extensive publications from the Cleveland School and that these publications will appear shortly. Possibly, as Dr. Todd predicts, they will bring order out of chaos and supply to Dr. Clark and others interested in endocrine dysfunction, an epiphyseal yardstick more dependable than anything now available. Certainly the development of such a yardstick is much to be desired.

DR. RALPH S. BROMER, Bryn Mawr, Pa. There are two points in Dr. Clark's paper which I think have occurred to you. I had the privilege of reading it this morning and so could appreciate it in its entirety and I think he has answered the first question which occurred to me, the question of the variations in time of the development of the epiphyseal centers. He says that very often a patient is examined and the child's age is given, for instance as eleven until his twelfth birthday is reached. This affords up until his twelfth birthday the possibility of an error of a year.

Second: In some of the various papers and charts which have been published, possibly some subclinical endocrine disturbances have been counted among the normal which might

account for a variation in time of the appearance of the centers.

Third: He says the influence of sex, race, climate and heredity have often been ignored in the publication of such charts.

I hope that Dr. Clark will not mind my answering this question for him inasmuch as he did not have time to cover this subject and it was brought out very fully in the paper. I think the question of his criteria for determining whether or not there is delay in the development of the centers occurred to many in the audience.

From birth to one year, he allows a discrepancy of three months; one to three years, a discrepancy of six months; from three to six years, a discrepancy of nine months; from six to twelve years, a discrepancy of one year; and from twelve to twenty years, a discrepancy of two years.

If you looked at Dr. Cleaves' exhibit, you will recall that he shows a boy of fourteen having more advanced development of the sacroiliac epiphyseal centers than another boy of seventeen. This exceeds Dr. Clark's criteria for that age limit by one year and is illustrative of the wide variation in the time of development.

The other point that occurred to me is the practical value of the roentgen examination in checking the result of endocrine treatment. I have had practical experience only with cretinism. In a child of eight months, the wrists of a child diagnosed as a cretin showed undoubted delay in the development of the centers. He was treated in the Out-Patient Department and owing to changes in the visiting staff, he was kept on thyroid extract for a space of two years before he was returned for a check-up roentgenological examination. The medication was very promptly stopped when a report was returned that the two and one-half year old child now showed the development of a child of six. This illustrates the value of frequent roentgen studies.

Dr. Oscar V. Batson, Philadelphia. For a good many years, Prof. T. Wingate Todd and his group of the Department of Anatomy at Western Reserve University have been studying the age order of epiphyseal union. In practically all of the animals investigated, the order of ossification is the same, that is, any particular epiphysis always appears in the same relative sequence in relation to other epiphyses. I have investigated a small series for the ossification of the wrist, over a period of two years. As far as could be determined, this series seemed to fit it with Dr. Todd's observations.

Dr. Clark (closing). I am very grateful to the discussants for their interesting remarks. I am not familiar with Dr. Todd's work, referred to by Dr. Hodges and Dr. Batson. I am convinced, however, that the sequence of appearance of the various centers is not constant according to roentgenologic data. As a matter of fact, departures from the so-called normal sequence are quite common in conditions where the germinal protoplasm is at fault and are not rare in perfectly healthy children.

I am pleased to know that Dr. Bromer is in agreement as to the normal limits for the different ages. It does not seem likely that further work will define the normal time of appearance and fusion any more precisely than the present standards. At any rate, it is important that we, as roentgenologists, report our findings relative to a relatively precise *optimum* age rather than a varying *normal* age. The clinician may then decide, after taking into consideration the factors of race, sex, climate, familial tendencies, etc., whether an individual's osseous development does or does not fall within normal limits.

THE PHENOMENA OF SHADOW ATTENUATION AND SUMMATION IN ROENTGENOGRAPHY OF THE LUNGS*†

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IT IS now a well-recognized fact that lung detail in an emphysematous area may fail to appear in the roentgenogram. This phenomenon has come to be spoken of as shadow attenuation due to emphysema. The opposite of this phenomenon is the appearance of otherwise invisible lung detail when projected into the shadow of another structure. This is the so-called shadow summation effect. The exact nature of these phenomena is, judging from comments in the literature, as yet poorly understood, and therefore their discussion should not be superfluous.

Perhaps it will not be amiss to begin with the history. From a study of the literature I concluded that pediatrists were first to take special notice of these phenomena. It would seem that the Heidelberg pediatrist Duken[1] was the first to point out the relation between these phenomena and the state of lung inflation. Certainly it was he who first emphasized the fact that the reason why the lung lesions are not visualized in some cases of early bronchopneumonia in children was that the lungs tend to be emphysematous under these conditions. After Duken, pediatrists began to mention these phenomena repeatedly, and often raised the question as to the underlying physical laws which would explain them. As far as I can see, however, nobody has explained these phenomena as yet. In the roentgen literature too these phenomena have repeatedly been mentioned. Indeed, in his classical monograph of 1901 Holzknecht[4] discussed these phenomena in the chapter on the general roentgen features of the lungs, but he did not make clear their relationship to the varying air contents of the lungs. Lenk,[7] an outstanding pupil of Holzknecht, in his excellent monograph of 1929 discusses particularly the summation phenomenon and quotes the experimental evidence of Jaksch,[5] and Fleischner and Pulgram[2] as having shown that artificial reduction of the amount of radiation may produce greater clarity of the lung markings. He points out that this peculiar phenomenon cannot as yet be explained. Pancoast and Pendergrass[8] described the non-appearance in the roentgenogram of the early pneumoconiotic lesions, due to shadow attenuation by simultaneous emphysema. Of particular interest is a piece of experimental work by Van Allen and Soo[9] who demonstrated very conclusively that "the shadow cast by air inflated substances in roentgenograms are lighter than they should be considering only the atomic weights and the masses penetrated by the rays." They conclude that there is no adequate explanation for this phenomenon.

Failure of the lung lesions to appear in the roentgenogram in many cases of bronchopneumonia in children was one of the chief problems chosen for investigation by Dr. Stafford McLean in 1929 when I joined him as L. Emmet Holt Fellow at the Babies Hospital, New York City. We made observations in many such cases of bronchopneumonia, analyzed hundreds of series of roentgenograms in a great number of which the lesions failed to appear in the early part of the disease. As a result of our observations and our discussions we developed a concept of the physical principles involved

* Dr. Stafford McLean, late Clinical Professor of Pediatrics of the College of Physicians and Surgeons, Columbia University, New York City, would be co-author of this contribution were he alive now. I dedicate it therefore to his memory which I cherish as that of a great physician, a rare friend, and a nobleman of the mind and heart.

† From the Tuberculosis Service, Bellevue Hospital, and the Department of Medicine of Columbia University, College of Physicians and Surgeons, New York City.

in these phenomena which required experimental proof. Unfortunately our plans of experimental study never materialized. In the years that followed I continued my studies begun at the Babies Hospital, at the Chest Service of Bellevue Hospital where we discussed these phenomena innumerable times. Here, Dr. James Alexander Miller* demonstrated to us many times that these phenomena are also responsible in adults for the roentgenographic features in many cases of every type of lung disease. Indeed it became clear to us that correct interpretation of lung roentgenograms is often impossible without proper appreciation of the roentgenographic phenomena here discussed. I wrote several memoranda on the subject, which were read by my associates, which I did not, however, publish for the reason that experimental proof of our concept on them was still lacking. It was not until recently that Dr. Franke (physicist of the roentgen tube producing plant in Hamburg, who is an authority on roentgen physics) began to study the roentgen-ray scattering phenomena in lung roentgenography. More recently I furthermore succeeded in getting Mr. Wilsey, physicist of the Kodak Research Laboratories, Rochester, New York, who is an authority on scattered roentgen rays, interested in this problem. The final exact answer to the questions is now being determined but there is already available ample evidence that our ideas about the nature of the phenomena were essentially correct.

With Dr. McLean we observed that the roentgenograms in early bronchopneumonia often showed a diffuse haziness throughout, which cleared up gradually as the bronchopneumonic nodules made their appearance in a later film simultaneously all over the lungs. In some cases all lung fields cleared up with the exception of one part in which a denser pneumonic infiltration appeared, and the case turned out to be a confluent localized pneumonia instead of disseminated bronchopneumonia. In the first hazy film there was always evidence of pulmonary hyperdistention (emphysema), which subsequently receded. The roentgen aspects of early bronchopneumonia were very much like those in some cases of asthma paroxysm or pulmonary edema, which I had previously often had occasion to see. As we analyzed these roentgenographic sequences time and again and began to contemplate the possible roentgen physical principles involved, we hit upon a comparison with an optical phenomenon bearing a striking analogy to these roentgen phenomena. We compared them with the phenomena of natural light coming through a haze or fog. We argued as follows: Since roentgen rays are but light rays of vastly greater penetration power, it is reasonable to compare the relationship between roentgen rays and lung tissue with that between light and fog. Now, in the case of light rays and fog the optical principles are as follows: The denser the fog, the lower the visibility, i.e., penetration (which in terms of photography means increased shadow-casting), while the more dispersed the fog particles are in the air, the greater the visibility (penetration) and the more will they appear only as a haze. The limiting phenomena are the completely light opaque cloud and perfectly transilluminated air (more correctly aerosol), which, as we know, still contains many water particles so finely dispersed that they can no longer be seen. It is most important to appreciate the principle that the exactly identical amount of particles, well transilluminated when dispersed in a large volume of air, may block the same intensity of light to a degree of almost complete opacity, if they are condensed within a thin layer of air. The underlying physical principle is that the same quantity of light will transilluminate a certain number of particles where it can pass them singly with sufficient amounts of air between them, but will fail to transilluminate the same number of particles if it has to pass them in close succession one after the

* I am deeply indebted to Dr. James Alexander Miller for his most stimulating interest which was so helpful in the continuation of my studies on this subject.

other, condensed in a thin layer. The optical phenomena of haze and fog, which can be often and easily observed, are well understood to be due to light dispersion. As water and dust particles begin to condense in the air and disperse a part of the light, they appear first in the form of a haze. With increasing condensation there gradually develop all the phenomena of a non-transparent fog in which most of the light has become dispersed. From all this there follows obviously the principle which holds true for the relationship between natural light rays and particulate matter in the air, that the greater the particle dispersion, the better the transillumination, and the greater the particle condensation, all the greater the ray dispersion, i.e., the poorer the transillumination.

With Dr. McLean we carried over this analogy to the relationship between roentgen rays and tissue particles and arrived at the conclusion that the greater the tissue condensation (the less the air content between the tissue particles), the greater the roentgen-ray dispersion (scattering), and the greater the lung inflation, i.e., the more the lung tissue is spread apart by intervening air spaces, the greater the roentgen transillumination of the lungs. The limiting phenomena here are the perfectly opaque airless lung and the perfectly transilluminated bullous emphysema. It is clear that in between stand the wide range of roentgenograms of varying detail in the lungs, proportionate with the wide range of variations in the state of pulmonary inflation. It is also clear that a normal lung picture may be produced not only when the proportion between tissue and air content is absolutely but also when it is relatively normal, as, for example, when both air and tissue contents are increased. This is just what happens in early bronchopneumonia when emphysematous overdistention of the lungs comes to compensate for the filling-up of many air spaces, with the result that the proportion between the amounts of tissue particles and air contained in the lungs remains the same. The roentgen picture of the lungs being essentially an expression of the proportion between its air and tissue contents, and since this proportion is not disturbed, the result is that we cannot visualize by roentgen rays the increase in tissue contents of the lungs in early bronchopneumonia. This is the explanation of the failure of roentgenography in early bronchopneumonia, as we conceived that at the time (about 1930–31). It also explains the first roentgen feature of bronchopneumonia, which is that of a diffuse haze due to increased scattering.

Thus the analogy to what happens to natural light in fog appeared to be perfect. On the basis of this analogy we assumed that scattering of the roentgen rays is in proportion to the air content of the lungs, that it increases with deflation and decreases with inflation. It also had to be assumed that in the lung roentgenogram, detail is rendered more by virtue of ray scattering than absorption, and that loss of lung detail associated with pulmonary hyperinflation is due to decrease in the extent of ray scattering which goes with increased air content, which explains the shadow attenuation effect of emphysema. Progressive deflation of the lung leads to increased scattering, and with this goes increase in detail rendition, which explains shadow summation by superposition of densities. Taking for granted that these assumptions were all correct, then for roentgen rays too there must be valid the principle established above for natural light, namely, the greater the particle dispersion, the better the transillumination, and, vice versa, the greater the particle condensation, the less the transillumination. In other words, a given amount of radiation which will transilluminate a certain amount of tissue distributed in space in a definite degree of dispersion will be stopped by that same amount of tissue condensed into one compact mass. Our most important assumption was, however, that the cause of these great differences in the penetrating power of the same amount

of radiation through the same amount of tissue substance, depending upon its dispersion in air space, was due to ray scattering.

The question whether roentgen-ray scattering in the lungs really plays the same important rôle as it does in the case of natural light in fogs had of course to be determined experimentally. We did not have the means for producing such experimental proof. However, just about that time, in 1930, there came to our aid two publications in the American roentgen literature. Leddy and Witting[6] reported experiments in which they determined the degree to which the intensity of radiation is enhanced by partial substitution of air for tissue. Weatherwax and Robb[10] studied the radiation intensity differences which exist between inflated and deflated lung tissue. Already from these experiments it became clear that scattering plays an important rôle in roentgen-ray penetration of lung tissue. More conclusive evidence did not become available until the later studies of Franke. The following is a literal quotation from a discussion by Dr. Franke[3] on the question of scattered radiation as a factor in roentgen picturization.

From the fact that roentgen visualization depends in final analysis upon interception of certain parts of the rays before they reach the film, it can be demonstrated that detail rendition in any lung roentgenogram obtained with hard radiation is due to scattered radiation. If differentiation by the picture-producing radiation were due chiefly to genuine absorption of the rays in tissue, then it would hardly be possible to obtain useful roentgenograms of the lungs with hard radiation. Experience shows, however, that when lung exposures are made with increased voltage (from 40 to 120 kv., the latter with Potter-Bucky diaphragm), although the contrast of the ribs decreases to the point of transparency, tissue detail within the lungs persists to an amazing extent. The explanation lies in the fact that visualization of the detail in soft tissue consisting of low atomic elements depends only to a slight extent on absorption but for the most part on reduction of the radiation by scattering. As Küstner's curves indicate, already at a tension of 60 kv., 80 per cent of the apparent ray absorption is due to scattering. In terms of physics this effect can be demonstrated by comparing penetration through an aluminum scale and a paraffin wedge. While under a 40 kv. exposure, 4 cm. paraffin and 1 mm. aluminum reduce radiation to the same extent, under a 120 kv. exposure (with Potter-Bucky diaphragm to intercept scattered radiation in paraffin), there is still an apparent reduction in paraffin, which amounts to an absorption in 5 mm. of aluminum. In other words, paraffin of light atomic composition affords more detail than does aluminum of high atomic weight. Aluminum may be compared with the ribs of the chest, while paraffin behaves as lung tissue does.

The experiments of Franke have thus proved conclusively our assumption that scattering is at the bottom of the peculiar roentgenographic phenomena in the lungs. With regard to the question of the exact rôle of the air content of the lung, Dr. Franke expressed himself as follows in answer to my question: "Whether the lung is inflated or deflated undoubtedly plays a rôle; inasmuch as in inspiration the lung expands in all three dimensions, it becomes thus more easily penetrable to the rays in every direction."

There was still left open therefore the question of the exact relationship between scattering and the air content of the lungs in various states of inflation and deflation respectively, which could of course be determined only by difficult roentgen-physical experiments. These experiments, which in part we have helped to plan, were recently undertaken by Mr. Wilsey, and so we may be confident that the problem will soon be cleared up in all of its aspects. The results of these experiments will show whether or not our assumption that detail rendition in the lung is not only due to roentgen scattering but that the latter is in reciprocal relationship with the state of pulmonary inflation was correct.

To conclude then, although we have not been able to contribute to the actual solution of the problem in question, we have on the basis of analogous optic-physical principles reached conclusions which enabled us to explain the phenomena of

shadow attenuation and summation in lung roentgenography. I offer this analogy here as an aid in the understanding of these phenomena of lung roentgenography which are not generally appreciated, much less understood.

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Vol. 35, No. 6

ROENTGENOGRAPHY IN OBSTETRICAL DIAGNOSIS*

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IN MARCH, 1896, Varnier and his associates[8] reported the results of the first roentgenographic investigation of a fetus through an exteriorized uterus at autopsy. At about the same time, Heinrichs demonstrated the roentgenogram of a fetus with hydrocephalus, scoliosis, spina bifida and talipes equinus. Because of numerous technical difficulties, these early studies necessitated exposures of about one and a half hours. Since that time the use of this physical agent has become such a valuable factor in obstetrical and gynecological diagnosis and therapeusis that mere enumeration of its uses would become most lengthy and monotonous.

When intelligently used, it has proved to be a most versatile diagnostic and therapeutic medium. In hypoplastic sterility we find it being used to stimulate the closely allied pituitary gland and ovaries. Again, we find it being employed to perform therapeutic abortions or to attenuate overfecund males.

In conjunction with the intrauterine injection of radiopaque solutions, much information may be obtained relative to the capacity or shape of the uterine cavity, the tonicity of the myometrium, or the patency and propulsive contractions of the fallopian tubes. The recent vogue for tubal plastic surgery occasions the need of hysterosalpingography for critical localization of occlusions and determination of the success or failure of surgery.

In this paper, it is my purpose to show concrete instances in which the roentgen ray has been a valuable adjunct in the diagnosis and handling of certain obstetrical problems.

The studies offered are from the combined services of Dr. Charles E. Ziegler and myself at the Elizabeth Steel Magee Hospital except in the cases noted. The roentgen interpretations were made by Dr. George W. Grier.

The use of roentgenography in obstetrical conditions has been arranged by Matthews[5] as follows:

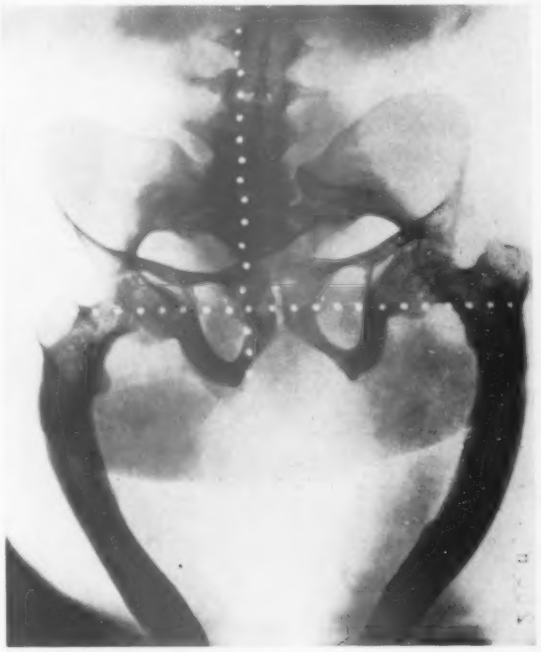
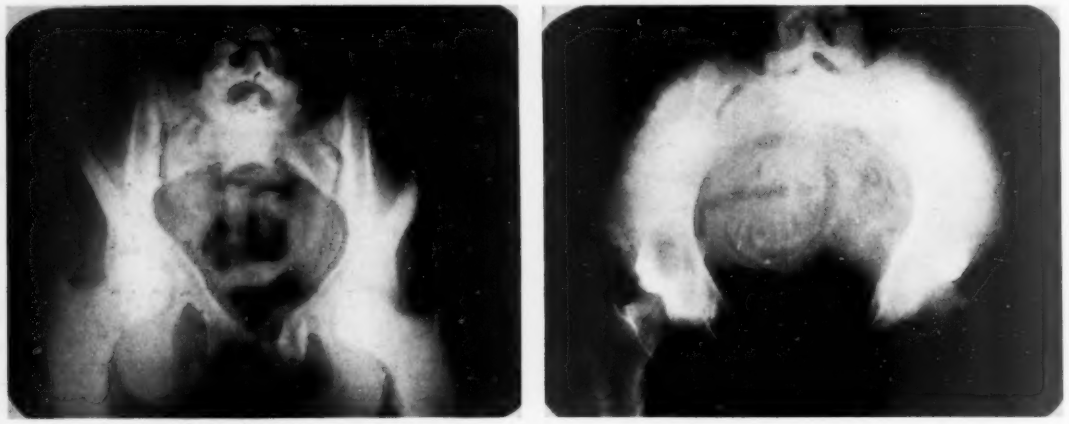


FIG. 1. Extreme degree of pelvic flattening due to rickets. Diagonal conjugate measures 3.5 cm. by the technique of Thoms.

1. Those relating to the maternal pelvis.
2. Those relating to extrauterine pregnancy.
3. Those relating to intrauterine pregnancy.
4. Those relating to pelvic tumors.
5. Miscellaneous conditions.

The Maternal Pelvis. Deformities of the maternal pelvis and moderate contractions of one or more diameters may be judged by study of the flat plate, but more critical study can, of course, be accomplished by means of stereoscopic films. Measurements

* Read before the Pennsylvania Radiological Society, Pittsburgh, Pa., May 18, 1935.



A *B*

Fig. 2. *A.* Multiple fracture in an immature pelvis of a sixteen year old girl. *B.* The same pelvis five years later, symmetry restored, transverse diameter contracted but the diagonal conjugate lengthened. Two vaginal deliveries.

of the pelvic inlet have been made according to the technique of Thoms and checked with reasonable accuracy. The recent work of Caldwell and Moloy[1] on roentgen pelvimetry by means of the precision stereoscope, I have studied in their clinic. To my mind, in experienced hands, this method is more exact than any so far propounded. Their classification of developmental types of pelves and their studies of cephalopelvic relations during labor should add greatly to our knowledge of operative obstetrics.

A *B*

Fig. 3. Abdominal pregnancy at term. *A.* Right acromio-dorso-anterior position. Uterine shadow absent. *B.* Extreme superficiality of fetal parts not obscured by amniotic fluid. (Eisaman and Ziegler.[3] Reproduced through the courtesy of the *Journal of the American Medical Association.*)

However, this method is costly and for this reason will not be accepted for general use at the present day.

In our series of cases studied are found end-results of those conditions, which, in the main, cause the great majority of pelvic deformities, namely, achondroplasia, rickets, tuberculosis and fractures. In some cases the clinical photograph has been included in order that the general condition can be more clearly visualized.

We have learned from examination of such pelves, particularly the obliquely contracted type due to severe scoliosis or scoliokyphosis, that vaginal delivery is frequently possible.

Another patient of Dr. Dodds' had suffered severe multiple fractures of the pelvic girdle at the age of sixteen. At this time the pelvis was most asymmetrical, badly deformed and all the pelvic diameters shortened. After a five year interval we were surprised to note that the pelvis had regained its symmetry, the diagonal conjugate had been materially lengthened and two pregnancies were successfully terminated by vaginal delivery.

Extrauterine pregnancy of some months' gestation may be positively demonstrated if this condition is given due consideration and is made more obvious by injection of the uterine cavity with radiopaque solution or the introduction of a sound. Several excellent examples of advanced abdominal gestation are included in this study. Figure 3, *A* and *B*, illustrates a full term living fetus lying within the peritoneal cavity.[3] Because of little or no liquor amnii the normal globular uterine shadow is absent and the fetal parts appear in sharp detail. These signs afford positive evidence of extrauterine pregnancy. In the second case[7] (Fig. 4), the fetal membranes were calcified during forty-two years of intraperitoneal existence and a lithopedion formed. The true nature and site of the fetal mass were proved by the injection of the uterine cavity with iodized poppy seed oil before exposure.

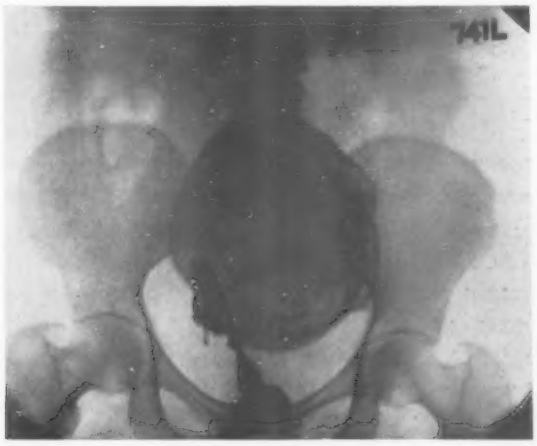


Fig. 4. Abdominal pregnancy, calcified and retained for forty-two years. Contrast medium proves mass to be outside of the uterus. (Titus and Eisaman.[7] Reproduced through the courtesy of the *American Journal of Obstetrics and Gynecology*.)

Fig. 5. Craniorachischisis in conjunction with polyhydramnios. Exposure after artificial rupture of the membranes.

Although we have observed[3] that advanced abdominal pregnancy is noted once in 10,000 deliveries, we believe that present day accurate diagnosis will materially reduce this ratio.

Intrauterine Pregnancy. This group affords many difficulties and anomalies and more accurate evaluation of the same assures greater safety for mother and infant.

In 1921, Peterson[6] diagnosed early (eight to ten weeks) intrauterine pregnancy by the roentgen ray after transabdominal pneumoperitoneum, and Heuser[4] in 1924 injected iodized poppy seed oil into the uterus as an aid in the roentgen determination of pregnancy. But according to Case[2] "Unless we admit the safety and desirability of the routine 'use of these methods' apparently it will never be possible to make a roentgen diagnosis of pregnancy before the end of the second month." Although these methods have been supplanted by the Aschheim-Zondek reaction, instances do arise, i.e., medicolegal testimony and pseudocyesis, in which more concrete evidence may be imperative.

The ability to determine the age of the fetus or post-maturity, multiple pregnancy, malposition or malpresentation, cephalopelvic proportion, particularly in obese women, needs no explanation.

Presumptive signs of pregnancy with positive Aschheim-Zondek reaction and absence of fetal parts justifies the diagnosis of hydatid mole. Intrauterine fetal death is evidenced by overlapping of the cranial bones, angulation of the spine and collapse of the thoracic cage. Some authorities have claimed the ability to demonstrate contraction rings of the parturient uterus.

Because of the certain proportion of fetal monstrosities associated with apparently normal pregnancies (estimated by Marchand as 616 in 81,157 births) we urge the roentgen study of all patients with indefinite position or presentation, polyhydramnios, or other irregularities, particularly if cesarean section or obstetrical operations are impending. Such procedure would at times permit us to wisely resort to another type of delivery than that intended, and suggest termination of pregnancy when malformation or non-viable fetus is present.

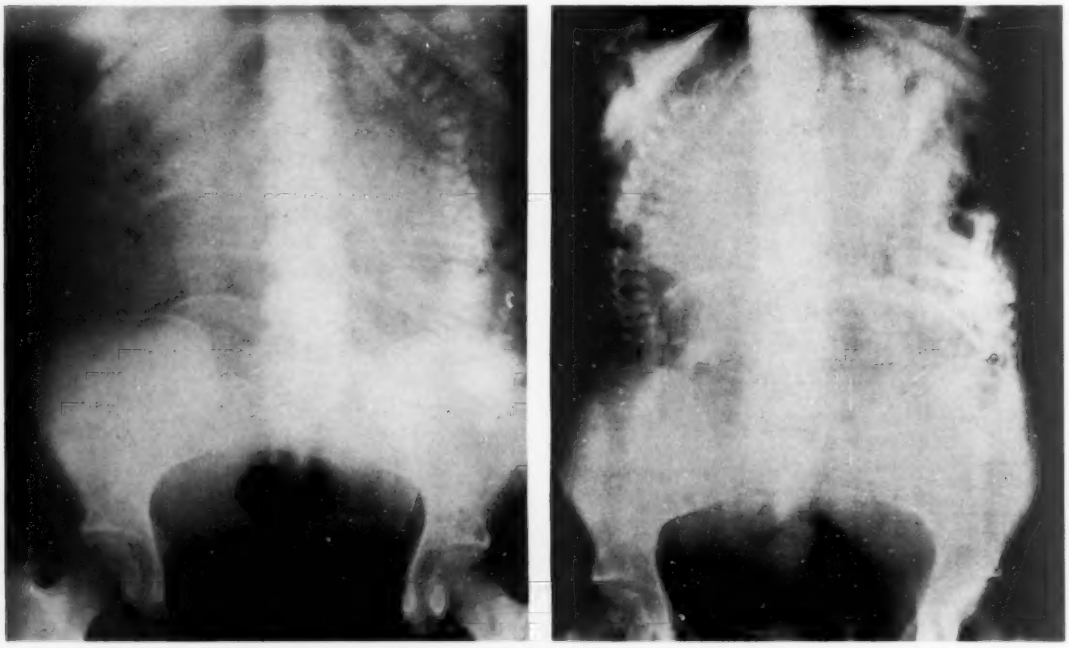


Fig. 6. Hydrocephalic infant. Interval exposure over a period of seven weeks shows evidence of progressive enlargement of the fetal skull with atrophy of the cranial bones.

In one case submitted by Dr. Martinez, a rigidly extended head due to spina bifida occulta of the cervical vertebrae was responsible for one of our most difficult vaginal deliveries. Earlier diagnosis would have justified craniotomy.

We are aware that polyhydramnios is so commonly related to fetal anomalies that we feel justified in rupturing the amniotic

sac before exposure if fetal parts are obscured by amniotic fluid on a previous film. On one occasion we aspirated amniotic fluid through the abdominal wall without inducing labor.

The study of the amniotic content following the injection of 10 per cent strontium iodide through the uterine wall may be of some avail in such instances. However, from a limited personal experience with this technique I feel that little is to be gained from the use of this rather formidable procedure other than the possible localization of the placenta, and inevitable fetal and maternal hazard. I am also convinced that placenta praevia can be more expeditiously and accurately diagnosed by careful physical examination than by the injection of sodium iodide into the bladder as a contrast medium.

A large and overriding fetal head may simulate hydrocephalus but diagnosis can be ascertained by visualization of atrophy and separation of the cranial bones. Undue rapidity of cephalic enlargement may be noted by recourse to interval exposures.

Pelvic Tumors. The diagnosis of pregnancy in the presence of pelvic tumor is often difficult but material aid is available by means of roentgenography combined with the transabdominal insufflation of carbon dioxide gas.

Miscellaneous Conditions. Naturally the obstetrical patient is subject to all of the pathological conditions found in the nongravid, but she does have a predilection for urinary infections and acute exacerbations of pain and hematuria from preformed calculi of the urinary tract.

There are likewise many fetal anatomical anomalies and defects (at times impossible to diagnose ante partum), which call for the aid of the roentgenologist. Of these we present several of the more important.

Diaphragmatic hernia is suggested by asphyxia, cyanosis, and dextrocardia.

An inordinate amount of mucus from the mouth of the newborn, with regurgitation of milk, should lead us to investigate the esophagus for a probable atresia.

Other pathological states of the newborn which lend themselves readily to roentgen study are fractures, tumors, hyperplasia of the thymus, atelectasis, congenital syphilis, and visceral anomalies.

Should autopsy permission be withheld in cases of neonatal death, roentgen investigation is of inestimable value in questionable live births. It is of even more value in the study of skeletal and vascular anomalies than careful dissection.

SUMMARY

As yet we are seeking for an adequate method of roentgenological pelvic and cephalic mensuration which will be economical and adapted to general obstetrical use.

Although we find this medium of investigation a valuable adjunct and safeguard to mothers and babies, its limitations must be admitted. And in those studies of cephalopelvic proportion we must still bear in mind the great importance of malleability of the fetal head, some widening of the pelvic joints and the propulsive force of the uterine contractions.

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RESEARCH ON THE PNEUMATIZATION OF THE NASAL ACCESSORY SINUSES AND OF THE MASTOID PROCESSES AND ON THE SHAPE AND DIMENSIONS OF THE SELLA TURCICA IN TWINS*

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PARTICIPATING in the work of investigation of twins, carried on in the Medico-Biological Institute, we have been studying the influence of heredity and environment on the diversity in the shape and in the pneumatization of the nasal accessory sinuses as well as the diversity in the pneumatization of the mastoid processes and in the shape and dimensions of the sella turcica.

TABLE I

AGE OF TWINS EXAMINED

	Under 5 years	6–10 years	11–15 years
I.T.	3	5	3
F.T.	4	8	1

The pneumatization and the shape of the accessory sinuses (frontal and maxillary sinuses) has been investigated in the case of 24 pairs of twins—11 of them identical twins (I.T) and 13 fraternal twins (F. T.).

Technique of the Investigation. Usual occipito-frontal roentgenograms.

* Having divided our material into three groups (Group 1 including the cases where the sinuses had the same shape and pneumatization; Group 2, including those differing by one of the indicated signs, and Group 3, those differing by two signs) we obtained the following results (Table II).

The analysis of the data obtained permits us to come to the conclusion that the paratypical factors are predominant in the origin of the diversity in the shape and in the pneumatization of the nasal accessory sinuses.

The investigation of the pneumatization of the mastoid processes has been carried on in 22 pairs of twins, 11 pairs being identical twins, and 11 pairs fraternal twins.

Technique of Investigation. Roentgenograms taken according to Sonnenkalb.

The results of the investigation were as follows:

Identical Twins.

1. Five pairs have both mastoid processes well pneumatized.

2. One pair has both mastoid processes sclerosed.

3. Two pairs have both mastoid processes well pneumatized in one twin, while the other twin's mastoid processes are of mixed type of pneumatization.

TABLE II

DATA OF THE INVESTIGATION OF THE NASAL ACCESSORY SINUSES

	Frontal sinuses		Maxillary sinuses	
	I.T.	F.T.	I.T.	F.T.
Complete similarity	5	6	6	6
Small difference	3	4	5	7
Great difference	3	3	—	—

4. Three pairs have both mastoid processes sclerosed in one twin, while the type of pneumatization of the other twin's mastoid processes is a mixed one.

Fraternal Twins.

1. Three pairs have both mastoid processes well pneumatized.

From the Roentgen Department (Prof. I. G. Dillon, Director) of the Medico-Biological Institute of Gorky (Prof. S. G. Levit, Director).

2. Two pairs have both mastoid processes sclerosed.

3. Two pairs have both mastoid processes well pneumatized in one of the twins and sclerosed in the other.

4. Two pairs have both mastoid processes sclerosed in one twin, the type of pneumatization in the other twin being a mixed one.

5. One pair has both mastoid processes of a mixed type of pneumatization.

6. One pair has in each of the twins one process pneumatized, while the other process is of a mixed type of pneumatization.

The described data are shown in Table IV.

The data obtained show that the diversity in the pneumatization of the mastoid processes depends chiefly on paratypical factors.

TABLE III

AGE OF TWINS EXAMINED

	Under 5 years	6–10 years	11–15 years
I.T.	3	5	3
F.T.	4	7	—

The shape and dimension of the sella turcica have been investigated for 26 pairs of twins, 12 pairs being identical twins and 14 pairs fraternal twins. The method of investigation consisted in taking films of the skull in perfectly identical position, the sagittal plane of the head exactly parallel with the cassette. The anode-film distance, 35 inches; the central ray directed on the sella.

Under these conditions we obtain the minimum distortion of the shape and dimensions of the sella.

The dimensions of the sella were measured in two directions.

1. *Sagittal Dimension.* The maximal anteroposterior dimension of the base.

2. *Vertical Dimension.* Distance from the middle of the base to the diaphragma of the sella, that is to say, to the line connecting the place where the planum sphenoidale reaches the base with the posterior cuneiform processes.

TABLE IV

DATA OF INVESTIGATION OF THE MASTOID PROCESSES

	I.T.	F.T.
Considerable similarity	6	6
Small difference	2	1
Great difference	3	4

The data obtained are given in Table VI. Comparing these data as obtained for I.T. and for F.T., we arrived at the following results.

The group "considerable similarity" includes the cases where the sella in one of the twins had the same shape and dimensions as the other twin; in the second group "small difference" we have included the cases differing by the shape and one of the dimensions; in the third group, the cases differing by the shape and both dimensions.

On the basis of the data obtained, we may come to the conclusion that the diversity in the shape and dimensions of the sella turcica depends in a great measure on genotypical factors.

The conclusions we arrived at do not disagree with the few data available in the literature on the subject.

Albrecht found (cited by Leicher) in 6 pairs out of 22 pairs of identical twins examined by him a partly unilateral, partly bilateral diversity in the pneumatization of the mastoid processes, which according to the author proves that the

TABLE V

AGE OF TWINS EXAMINED

	Under 5 years	5–10 years	11–15 years
I.T.	3	6	3
F.T.	4	9	1

TABLE VI

DATA DETERMINING THE SHAPE AND DIMENSIONS OF THE PITUITARY FOSSA

Identical Twins

	Name	Age Years	Sella turcica		
			Shape	Dimensions	
				Sagittal	Vertical
1	Yourij	4	Round	4	5
	Anately		Round	4	5
2	Youry	4½	Round	7	5
	Andrey		Round	7	5
3	Georgij	5	Round	8	6
	Anatelij		Round	8	6
4	Vera	7	Flat	9	6
	Nadia		Flat	9	6
5	Vladimir	7	Oval	11	6
	Sergej		Oval	11	6
6	Militza	8	Flat	9	7
	Arianda		Round	9	6
7	Vera	8–4	Flat	13	7
	Sania	mo.	Flat	13	8
8	Nicolai	9	Round	11	8
	Alecsej		Round	11	8
9	Efim	10	Flat	11	6
	Semen		Flat	11	6
10	Alexander	12	Round	7	5
	Vietor		Round	7	6
11	Ivan	13	Oval	11	7
	Alecsej		Oval	11	7
12	Maria	14	Oval	12	8
	Xenia		Oval	12	8

Fraternal Twins

1	Zina	3–2	Round	11	7
	Vera	mo.	Round	11	7
2	Rumb	4½	Flattened		
	Alpha		Round	10	6
3	Alexander	5½	Round	8	5
	Boris		Oval	7	6

Fraternal Twins (*Continued*)

	Name	Age Years	Sella turcica		
			Shape	Dimensions	
				Sagittal	Vertical
4	Maria	5½	Round	10	6
	Nina		Round	10	6
5	Valia	6	Round	10	8
	Vassia		Oval	10	6
6	Ira	6	Round	8	7
	Evguenia		Oval	10	6
7	Valentina	7	Oval	11	6
	Antonina		Oval	11	6
8	Lilia	7	Round	10	6
	Vitia		Round	9	5
9	Xenia	7	Round	8	6
	Olog		Flat	10	4
10	Nicolai	8	Flat	10	5
	Anately		Flat	10	7
11	Serguej	8½	Oval	13	8
	Semen		Oval	13	8
12	Gleb	9	Flat	10	5
	Boris		Round	10	7
13	Natalia	10	Round	8	8
	Maria		Flattened	10	6
14	Luba	13	Flat	11	6
	Nadia		Flat	13	6

pneumatization of the mastoid processes depends not only on genotypical factors, but also on the paratypical influence.

Leicher found in 14 pairs out of 39 pairs

TABLE VII

DATA OF INVESTIGATION OF THE PITUITARY FOSSA

	I.T.	F.T.
Considerable similarity	9	4
Small difference	3	6
Great difference	—	4

of identical twins examined by him a considerable difference in the pneumatization of the mastoid processes.

Schwarz (cited by Leicher), having examined 59 pairs of identical twins and 35 pairs of fraternal twins, found in 50 per cent of the identical twins and in 37 per cent of the fraternal twins a great similarity in the size and in the shape of the frontal cavities, and in 68.2 per cent of the identical twins and 50 per cent of the fraternal twins a great similarity in the shape and in the size of the maxillary sinuses.

Leicher found in 13 pairs out of the 39 pairs of identical twins an almost complete similarity in the size and in the shape of the frontal sinuses.

Maguid found a great similarity in the shape and dimensions of the sella turcica in 4 pairs of identical twins and a great difference in 4 pairs of fraternal twins which he investigated.

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THE EFFECT OF ROENTGEN IRRADIATION ON EXPERIMENTALLY PRODUCED POLYCYTHEMIA IN RATS WITH SPECIAL REFERENCE TO BLOOD AND BONE MARROW*

By EUGENE DE SAVITSCH, MOLLY RADFORD, BERGET H. BLOCKSOM, S. P. PERRY, *and* NATHALIE TUPIKOVA
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THE production of experimental polycythemia by the administration of cobalt salts has been demonstrated by several investigators.[3,4,7] In our series of experiments the polycythemia so produced was accompanied by a relative though variable leukocytosis.

These findings led us to believe that this property of cobalt salts might find a practical application in preventing the secondary anemia, and possibly the leukopenia, incidental to the use of intensive irradiation in the roentgen therapy of tumors.[1,2,6]

The general plan of experimentation was to produce a definite polycythemia in rats and subsequently to subject them to intensive roentgen irradiation.

Thirty-six young adult male albino rats of approximately the same size were divided into three groups. Groups I and II received daily subcutaneous inoculations of 0.5 mg. of cobalt each in the form of 0.25 c.c. of an aqueous solution of cobaltous chloride. Group III received no cobalt. The animals were kept on standard laboratory rations with no attempt to restrict their diet. Erythrocyte and leukocyte counts were made at convenient intervals. The erythrocyte counts were made with Thoma pipettes and a 1:200 dilution of blood with Hayem's solution. Leukocyte counts were made in a similar manner with 1:20 dilution of blood in 2 per cent acetic acid. A Levy-Hauser hemocytometer chamber with the improved Neubauer ruling was used for the counting. From previous experience we found that the easiest and most effective method of obtaining blood was by cutting the tail. In only a few instances late in the experiment did we resort to cardiac puncture when accidental infections of the tail prevented using the simpler method.

At the end of twenty-nine days of cobalt administration the erythrocyte counts in Groups I and II averaged 10,410,000 and 10,685,000 respectively. The leukocyte counts of these groups averaged at this time 25,425. Far greater variation was found in the leukocyte counts at all times than in erythrocyte counts; however, in each case the low counts were the exception rather than the rule. Averages for the normal control rats were: erythrocytes, 6,560,000 and leukocytes, 12,725.

On the twenty-ninth, the thirty-second and the thirty-sixth days following the beginning of the cobalt injections, the rats in Groups I and III were subjected to roentgen treatment with 300 r, each rat receiving a total of 900 r in a period of one week. The irradiation was given to the body from the level of the diaphragm caudally, to and including both lower extremities and the tail. It was produced at 200 kv. with 25 ma. of current filtered through 0.5 mm. of copper and 1.0 mm. of aluminum. The intensity of 30 cm. focal skin distance as determined in air with a Westinghouse Integrating Dosage Meter was 100 r per minute. The mean effective wave length was 0.16 Å. as evaluated by a copper absorption curve. A Picker-Waite half-wave rectification valve tube "voltage doubling" generator was used as a source of current. The roentgen rays were produced by an oil-cooled General Electric XPT tube housed in a shock-proof stand.

The portal through which the irradiation

* From the Department of Physiology of the University of Chicago.

was delivered was selected for two reasons: (1) rats do not tolerate total body irradiation very well;[5] (2) the portal included a large percentage of the animal's bone marrow as well as the spleen and the liver.

After a considerable interval in which the blood counts were followed in their downward course, and during which a number of rats died, the remaining animals in Groups I and III were given 400 r on the sixty-fourth day and 500 r on the seventy-fifth day of cobalt inoculation.

Accompanying graphs show average erythrocyte and leukocyte counts throughout the period of inoculation and roentgen irradiation. Likewise mortality curves for each group are shown in relation to the experimental procedures.

The results from a purely practical point of view were not satisfactory not only because the polycythemic rats showed a more rapid and more extensive fall in erythrocytes and leukocytes following irradiation, but also because the mortality of the animals in the experimental group was far in excess of that in either of the control

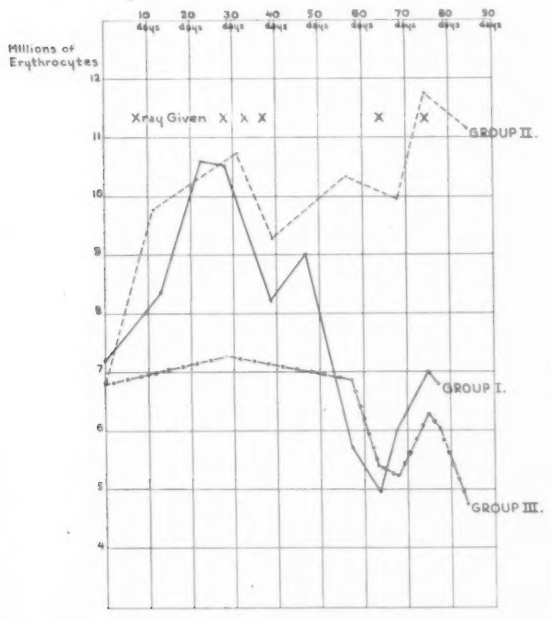

Chart I. Erthrocyte curves throughout period of cobalt administration. Group I received cobalt and roentgen irradiation. Group II received cobalt only. Group III received roentgen irradiation only.

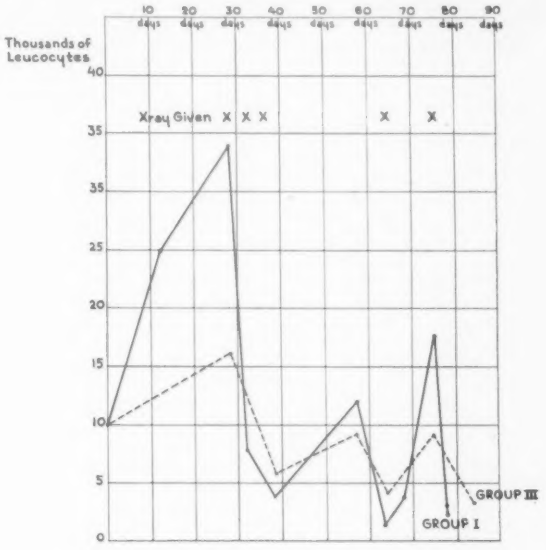

Chart II. Leukocyte curves throughout period of cobalt administration. Group I received cobalt and roentgen irradiation. Group III received roentgen irradiation only.

groups. In fact, only one animal in Group I survived the entire period of irradiation, whereas the mortality in the normal irradiated animals was only 10 per cent for the same period, and that in the cobalt control group was 30 per cent.

To check further our experiment, sections were made of the bones of representative animals from each group on the thirty-sixth and sixty-fourth days of the experiment. They were studied with respect to the effect on the bone marrow of both cobalt and irradiation. Since there was found to be no significant difference in sections taken from a given group at the two stages of the experiment, the detailed explanation for the two periods will be omitted. In addition to these sections, previously prepared slides of marrow from normal untreated rats were available for comparison. Studies were made of the long bones, lumbar vertebrae, both proximal and distal caudal vertebrae, femur, tibia, and hind foot. In the irradiated animals additional sections of the front foot, radius, and ulna were made in order to demonstrate possible differences between the irradiated and shielded parts. In all cases

the complete bone containing the marrow was fixed in formalin-Zenker's, decalcified in 5 per cent nitric acid and subsequently treated with alcohol, acetone, and xylol, and imbedded in paraffin. Sections were cut at approximately 7 micra and stained with hematoxylin and eosin.

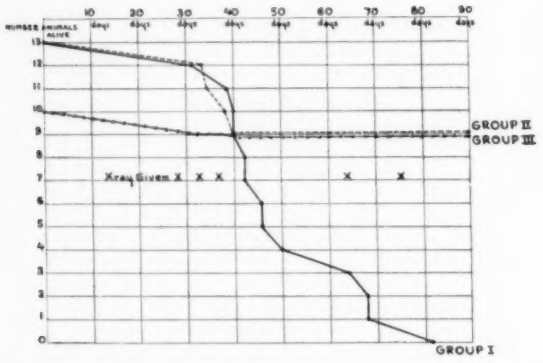

CHART III. Mortality curves of each group showing rate of death of rats in relation to experimental procedures. Group I received cobalt and roentgen irradiation. Group II received cobalt only. Group III received roentgen irradiation only.

In the animals of Group II receiving only cobalt, the marrow of the lumbar vertebrae, femur, and tibia was completely hyperplastic as judged by the absence of fat cells and the abundance of hemopoietic cells showing many mitotic figures. The hemopoietic cells showed all stages of maturity, ranging from the very early, almost undifferentiated forms, to mature cells of the red and white series; however, the younger types were far more prominent than is usual in normal marrow. The bones of the hind foot and the proximal caudal vertebrae showed a gelatinous type of marrow with a few scattered centers of proliferating hemopoietic cells. The marrow of the distal caudal vertebrae was completely fatty. In normal animals the picture differed in that even the most hyperplastic marrow contained a few scattered fat cells, and became progressively more fatty as the distal end of the tibia was approached; moreover, the distal end of the tibia, the bones of the foot, as well as the bones of the tail, were completely fatty.

In the irradiated animals of Group III which had received no cobalt, those bones below the level of the diaphragm which had been exposed to roentgen irradiation showed a distribution of marrow approximately like that in the normal animals. However, here there was marked evidence of degeneration of the hemopoietic cells in the pale-staining cytoplasm and dechromatized nuclei. In spite of this obvious process of degeneration and lysis, there was practically no sign of phagocytosis. The marrow as a whole was very edematous and there were great numbers of dilated blood spaces filled with red blood cells and a pinkish staining albuminoid material. Scattered islands of regenerating hemoblasts were seen mostly at the periphery of the marrow, but they occupied only a small fraction of the total area. (One animal was killed forty-eight hours, and the other seventy-two hours following irradiation.) In the radius and ulna, which had been shielded from irradiation, the marrow was completely hyperplastic and even the marrow in the bones of the front foot showed a few hemoblasts and an occasional megakaryocyte. In the normal rats the radius, ulna, and foot contained only completely fatty marrow.

In the animals of Group I which had received both cobalt and irradiation, the marrow picture of the irradiated bones below the level of the diaphragm was similar to that in the previous group (III), with the exception that the red marrow was somewhat more hyperplastic proximally and showed some distal proliferation. The non-irradiated bones of the foreleg and even the foot showed a completely hyperplastic marrow.

Animals injected with 2 c.c. of 12.5 per cent India ink on two occasions and killed and cleared by the Spalteholz method confirmed the histological findings by showing the distribution of reticulo-endothelial cells of the marrow to correspond closely with the distribution of red bone marrow in Group III and Group II.

SUMMARY AND CONCLUSIONS

1. Cobalt-produced polycythemia with accompanying leukocytosis in rats does not increase the tolerance of the rats to roentgen irradiation.

2. The erythrocyte counts in polycythemic rats are depressed to the same level as in the normal rats when both are subjected to roentgen irradiation.

3. In spite of the leukocytosis in rats receiving cobalt, the leukopenia produced when they were subjected to roentgen irradiation is even more profound than that produced in normal rats given the same amount of irradiation.

4. The survival period of irradiated rats with experimental polycythemia compares unfavorably with that of the normal irradiated controls.

5. Cobalt does not enhance the regeneration of hemopoietic bone marrow following irradiation.

6. Whereas the bone marrow of the shielded parts of animals subjected to irradiation undergoes some compensatory hyperplasia, the corresponding bones of polycythemic animals, under the same conditions, show even more extensive compensatory response.

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CEREBRAL ROENTGENOSCOPY AS AN AID IN PNEUMOVENTRICULOGRAPHY AND ENCEPHALOGRAPHY*

By A. J. BENDICK, M. D., *and* BEN H. BALSER, M. D.
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THE IMPORTANCE of pneumoventriculography and encephalography in the diagnosis of lesions of the central nervous system makes it desirable to develop any improvements in the technique of this procedure which will render diagnosis more accurate. There are two aspects to the technique, first, the method of air injection

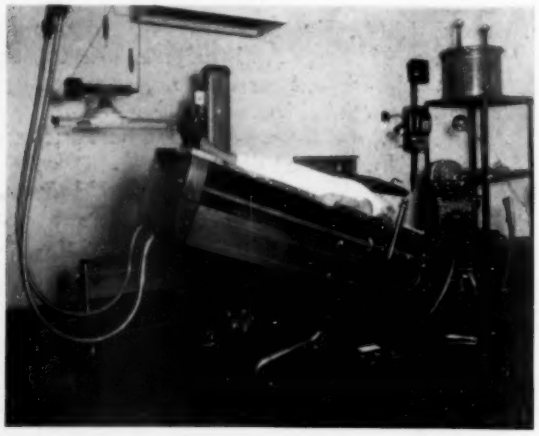

FIG. 1. Motor driven tilt table, transformer and movable control stand.

and, second, the manner of exposing the roentgen films, each of which is of importance to the final diagnostic result.

In regard to the method of injecting the air, in 1918 Dandy,[2] after experimenting with various media, reported the results he obtained by the injection of air directly into the ventricles. In 1919 he[3] supplemented this by his studies on the injection of air into the lumbar subarachnoid space. The technique for ventriculography consists of the injection of air directly into the ventricles through a single or double trephine opening in the skull over the posterior horns of the lateral ventricles. Different operators have chosen either one or two openings and have varied the location of the trephine opening. Whatever the details of the operation, the purpose in all cases is to inject the air into the posterior horns.

The technique for the injection of air into the lumbar subarachnoid space has also varied with different operators. Pancoast and Fay[5] make use of two needles, one of which is attached to a manometer for the observation of intraspinal pressure. Others use a single needle with a direct slow replacement of spinal fluid by air, attaching the manometer by means of a "Y" tube or a three-way stopcock. Because of the great change in blood and cerebrospinal pressures we have made use of the simple slow replacement method without constant observation of the pressure by means of a manometer. With this technique we have had no untoward results.

In regard to the roentgenological aspects of the technique with which this paper is mainly concerned, in 1927 Pendergrass[6] made use of a Potter-Bucky diaphragm which was placed over the head of the recumbent patient. The Potter-Bucky was supported in a sling and was suspended over the head with the roentgen tube below. Because of the natural ascent of the air, it was possible in this manner to place the film nearest to that part of the ventricle in which the air tended to collect. Pendergrass stated that "such an arrangement has made it possible for us to make more accurate interpretations of the roentgen films as by this method the air filled ventricle is nearest the film. The shadow of the air in the ventricle is more dense and distortions can be more easily seen." In 1931 Camp and Waggoner[1] devised a special chair to control the position of the patient

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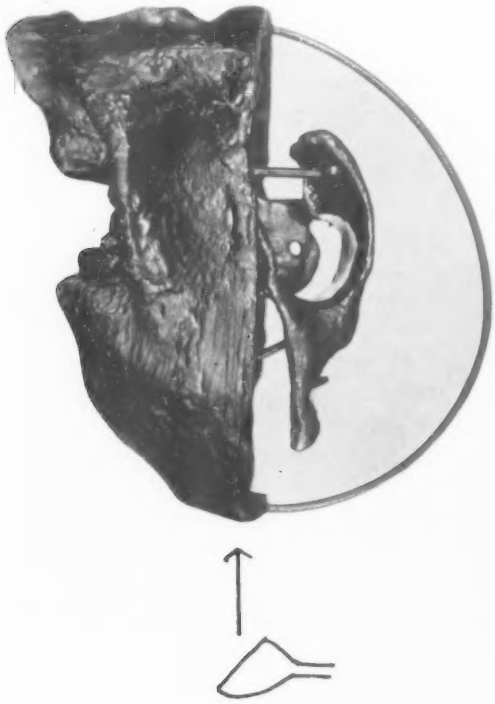
during the air injection and while the films were being taken. A separate stand was used on which were mounted the Potter-Bucky diaphragm, the cassette holder, head holder and roentgen tube. The separate units on this stand were so arranged that the distance from the tube to the film was constant, and it was therefore felt that this device would permit standardization of measurement. Epstein and Hanflig[4] in 1933 also introduced an adjustable chair to facilitate the technical procedure.



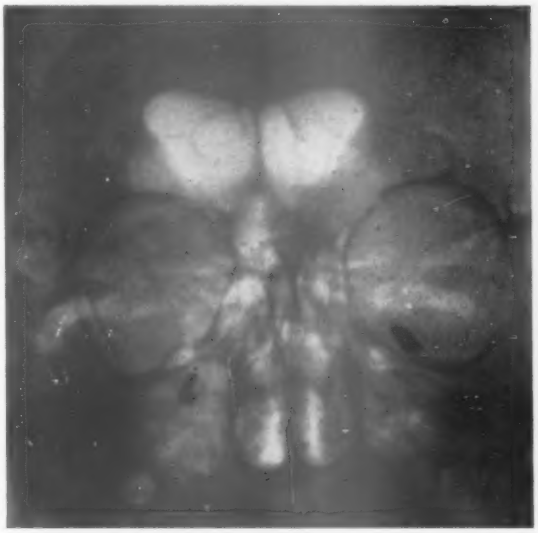


FIG. 2. Proper position of head and roentgen film for obtaining view of anterior horns of lateral ventricles.

The technique for pneumoventriculography and encephalography which we herewith present is based upon the use of roentgenoscopy for the localization of the air in the ventricles preceding the taking of the roentgenogram. It appears that this adjunct to a proper localization of the air has not heretofore been made use of. This is surprising because the entire ventricular system, when injected with air, is readily visualized on the fluoroscopic screen. In short, our method is entirely comparable to the roentgenoscopic visualization of the duodenal cap as a preliminary to the making of a roentgen film of this region. Its advantage in this field of diagnosis is that it is possible to vary the position of the head in such a way that air can be made to enter the particular portion of the ventricular system which it is desired to study and, having achieved this position, to register it immediately upon a roentgen film.

TECHNIQUE

We make use of a motor driven tilt table and a four-valve oil immersed roentgen transformer. The control stand is wired to permit of a rapid change from roentgenoscopy to roentgenography. This change is made by means of a switch installed on a movable control stand. The settings for roentgenoscopy and roentgenography are separately made before the operation so that no further adjustments are necessary once the examination is started. Five milliamperes are used for roentgenoscopy and 100 ma. for roentgenography. The spark gap varies from 68–80 kv. The exposure is one-quarter of a second. Although the time could be materially shortened, it is desirable to maintain this longer period because one can thus see

the image on the screen while the roentgen film is being exposed. If the time is shortened this is not possible. The fluoroscopic screen is provided with grooves beneath it to hold the cassettes. Fast, double intensifying screens are used without a Potter-Bucky or grid screen.

The air is usually injected while the patient is in the ward; he is thereafter brought to the roentgen department. As much as possible of the spinal fluid is replaced with air. It has been found that an average of 120 c.c. of air is most favorable for accurate diagnosis; although as little as 50 c.c. of air has been used occasionally, this is less satisfactory.

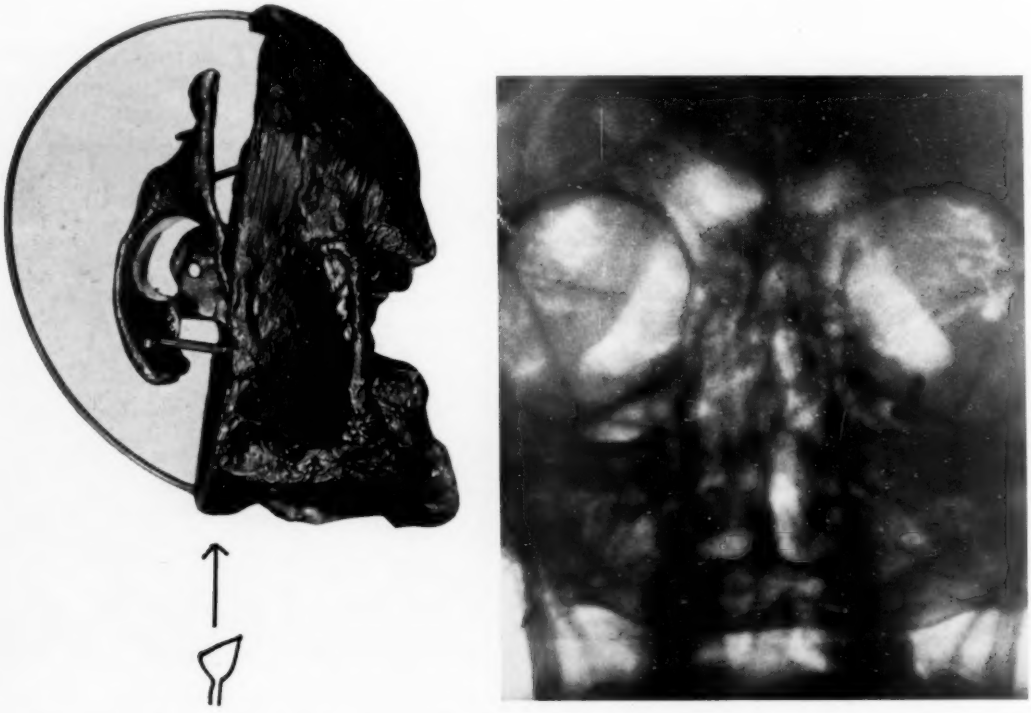


FIG. 3. Proper position of head and roentgen film for obtaining view of posterior horns of lateral ventricles.

The actual technique of the roentgen examination is as follows:

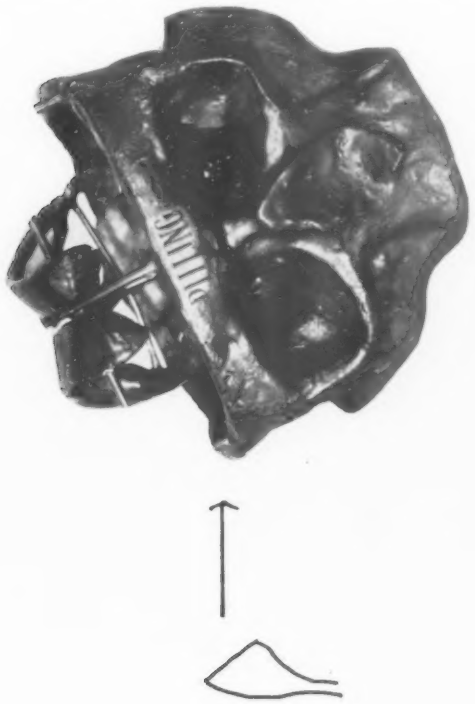
The patient is first placed in a special chair and preliminary Potter-Bucky films are taken. These are made in the anteroposterior and posteroanterior positions and also a stereoscopic set in the lateral position. The patient is then taken to the roentgenoscopic room and meanwhile these films are developed while our eyes are becoming accommodated for further examination. The purpose of the preliminary films is to afford a general idea of any pathological process in order that at the later examination we may center our attention on such abnormal areas of the brain. The patient is now transferred to the tilt table. A compression band is placed over his chest and shoulders to immobilize him. Small lead letters "L" and "R" are fixed with adhesive straps to the skin just lateral to the alae nasi. This is for the identification of the sides of the head, and also during roentgenoscopic examination it enables us to place the head in a true anteroposterior or lateral position.

In order to visualize the anterior horns the patient is placed on his back and for the posterior horns he lies on his abdomen. The lateral horns are demonstrated by rotating the patient's head first to one side and then to the other. Films are made in all of these four positions while the table is tilted both in the extreme Trendelenburg and semi-

erect positions. All the films are developed before the patient leaves the roentgen department.

The advantages of this technique are the following:

1. The observer may determine by preliminary roentgenoscopy the particular view of the ventricles of which he wishes to make a roentgenographic record. The latter is, therefore, no longer subject to chance.



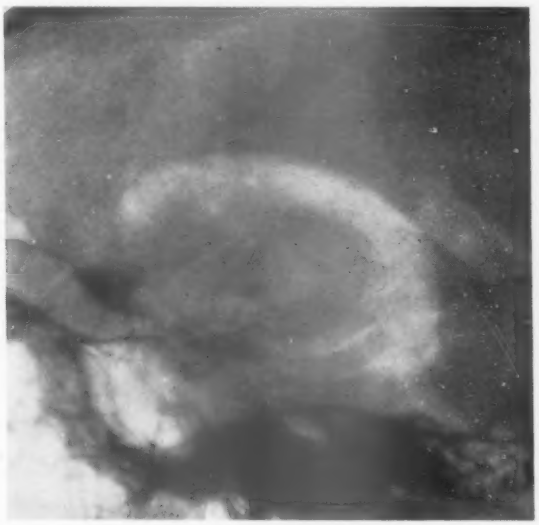


Fig. 4. Proper position of head and roentgen film for obtaining view of temporal horns as well as the fourth ventricle and iter.

2. The use of a tilt table obviates any exertion on the part of the patient during change of position. It is also comfortable for the patient; he need only change from the recumbent to the prone position.

3. By dispensing with the Potter-Bucky diaphragm the amount of roentgen exposure to the patient is reduced to about one-third. As a result more small films can be taken. By close diaphragming of the shutters there is no overlapping of the fields as in the routine method.

4. By means of the tilt table, owing to the ascent of the air, it is possible to place the film in close apposition to the area desired to be studied and thereby to obtain a sharper image.

5. By placing the patient in the extreme Trendelenburg position the basilar cisterns and inferior portions of the brain are much better visualized. A better study of these regions we believe will open up an entirely new field for diagnosis.

6. Roentgenologists have long known that in sinus examinations films of the head closely diaphragmed provide better diagnostic detail. The Potter-Bucky diaphragm has obvious disadvantages; it erases slight changes in density, and while Potter-Bucky films have greater contrast they supply poorer diagnostic detail.

7. Because a constant distance is maintained between the film and the tube the technique of ventricular and cisternal measurements can be standardized. The tube is at a fixed distance from the table top and therefore the tube to screen distance is fairly constant.

The only disadvantage that we have noted in our technique is that the general survey of the subarachnoid space is less satisfactory. However, for visualization of this region we make use of our preliminary

Potter-Bucky films. We are experimenting at present with a larger film and a Lysholm grid in the hope that this double procedure may be obviated.

SUMMARY

1. A method for the aerographic study of the brain is described in which the parts are studied both by Potter-Bucky and plain films in all the various positions of the head.

2. A technique for cerebral roentgenoscopy is outlined.

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SOME DISCREPANCIES AND PITFALLS THAT OCCUR IN CLINICAL WORK AS THE RESULT OF THE GRADING OF TUMORS*

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THERE has been among pathologists, since the time Rudolph Virchow laid the foundations of histology, a constant urge to express an opinion of the probable outcome of a case of malignant disease based on certain features of the microscopic structure of the tumor. Virchow wrote of a scale of malignancy but yet he himself emphasized that malignancy cannot be decided according to any fixed rule.[27] To mention others who recognized and wrote about the relation of histological structure to clinical malignancy would be but to recite the names of those who have been illustrious in the field of neoplastic diseases. The historical aspect of this subject is too well covered in the recent publication of Plaut[21] to permit a repetition. This much may be said that, until the time of Broders, apparently no one attempted to reduce the histological evidences of the degree of malignancy to simple terms. He published the first results of the application of his method on cancer of the lip in 1920.[1] Slowly Broders' method of grading has been adopted and recommended by pathologists and surgeons until now, fifteen years later, not only is it widely used in the prognosis of individual cases but also as a guide to treatment.

That the histologic grading of tumors is not a wholly reliable guide in either is evidenced by the modifications that have been suggested by Schmitz and Hueper,[13,14,25] Martzloff[17] and others, and by the praiseworthy critical review of Plaut,[21] Reimann[24] and Hellwig.[12] Lest there be some who are still unfamiliar with the principles of grading, a brief review is in order.

After fertilization of the ovum, the fertilized cell divides and re-divides, forming a solid mass of undifferentiated cells which might be compared to a sphere of marbles morphologically. All cells look alike, destined though they may be to form greatly varying tissues and endowed with all the inherited characteristics of the animal. Soon certain groups of cells begin to show differences in appearances, forming three distinct layers: an outer ectoderm being the protective layer and an inner endoderm lining the primitive gut tract, and in between the two a middle layer called the mesoderm. As the embryo develops, from the ectoderm the hair follicles, sweat glands and sebaceous glands differentiate, each with their characteristic cells, while from the endoderm the digestive organs, and from the mesoderm the blood vascular system, the muscles and the bones arise.

As the cells of the triploblast mature or differentiate, their differentiation is always progressive and never reversible or retrograde, but for each type of tissue there is ultimately a distinct formative cell in the adult whose duty it is under ordinary circumstances to give rise to the adult cell, to replace those lost by wear and tear or metabolism. This cell is represented by the basal cell of squamous epithelium or basal cell of glands and mucous membranes (better spoken of here as the generative cell), and also fibroblast of connective tissue. Neoplasms may result when cells of an embryo still undifferentiated become dormant, ceasing to grow or mature until some time in post-uterine or adult life, when they awaken, as it were, to begin where they had left off. Growing in a strange environment, adult instead of embryonic tissue and more than likely under altered chemical conditions they grow

* Read at the Thirty-sixth Annual Meeting, American Roengen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

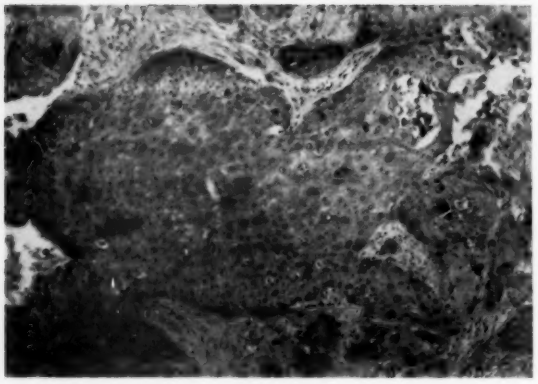

FIG. 1. Carcinoma of the larynx, Grade 1, showing epithelial pearls and keratinization.

atypically. This is the cell rest theory of neoplasm and probably accounts for the rodent ulcer type of basal cell carcinoma, hypernephroma and embryomas of the testicles. It is not likely that all tumors have such an origin but some arise because of altered metabolism from cells that have been entirely normal. Then instead of the proliferating cell maturing to the adult form it seems to have lost its ability to mature and retains only its ability to reproduce. These cells may look like embryonic cells but they are not subject to the limitations of growth that govern cells in the embryo or the adult. Nor do they possess the potentialities of the embryonic cell of differentiation into one or several kinds of tissue that will possess a definite function. The less the ability of the cell to differentiate, the greater is the disturbance of cellular metabolism and the greater this disturbance, the more vicious is the tumor that results from such a cell growth apt to be. Complete differentiation is recognized by the normal adult characteristics of the cell. In squamous epithelium it is the ability to form keratin and intercellular spines. In glandular epithelium it is the ability to line glands in an orderly fashion and to produce a specific secretion. In muscle it is the ability to form muscle fibers and in connective tissue to form collagen. Mature, resting cells show a definite proportion between nucleus and cytoplasm, while the immature cell possesses a very large nucleus and nucleolus, so-called one-eyed cells. Immature nuclei stain more deeply than mature. Proliferating cells are by their nature immature, showing many mitotic figures. Undifferentiated cells of squamous carcinoma show disproportion between size of nucleolus, nucleus and cell. They do not produce keratin or intercellular spines. They lack cohesive property and do not stratify. In adenocarcinoma the inability of the cells to form glands and their occurrence in compact masses is the expression of undifferentiation. It is upon these long-known principles that Broders' method is based. He teaches that if 100 to 75 per cent of the cells of a tumor are differentiated adult forms this constitutes Grade 1; in Grade 2, 75 to 50 per cent of cells are differentiated and 25 to 50 per cent undifferentiated. In Grade 3, 50 to 25 per cent are differentiated and 50 to 75 per cent undifferentiated, while Grade 4 is 75 to 100 per cent undifferentiated.[2]

It is surely evident from the many studies reported that grading of tumors as a group will show the average age expectancy of life for that group. That is to say, the average length of life in a group of Grade 1 tumors will be longer than the average for a group of Grade 2 or 3 tumors; and also the average percentage of metastasis in Grade 2 will be greater than the average in Grade 1 tumors. But that these observations are not constant and therefore not applicable to the individual case may be shown by a review of recent publications.

It is to be understood that this analysis is not to be construed as criticism of the publications mentioned. It is to call attention to discrepancies which some authors themselves have noted in their summaries.

A point worthy of emphasis is the fact that Broders' original study was made upon cases that did not have the advantage of modern roentgen and radium therapy, and it is possible even what was available was not used until late in the disease. It is not astonishing then that today more cases of the higher grades of malignancy survive for a longer period or are completely cured. There are many factors that exert a

decided influence on potential malignancy. These are some notable exceptions that apply wherever malignant lesions occur.

The histologic picture is not always uniform (Jones,[15] Reimann,[24] Gates and Warren,[9] Hellwig[12]) so that unless biopsy is selected from several areas in a tumor an accurate sample is not obtained. Figure 1 shows an area in the larynx which might properly be called Grade 1, while another fragment removed a few millimeters distant shows less typical cells, as seen in Figure 2. It must be evident then that a single biopsy may not show the predominating cell type and therefore not the true grade of a tumor. Gates and Warren[9] recommend that one select the most malignant-looking area, which should never be less than one-third of the tissue examined, and that the degree of malignancy then must be tempered by what is found in the remainder of the section.

The presence or absence of metastasis has an important bearing on the outcome of a case. The microscopic picture does not give any indication as to whether metastasis has occurred. Bloodgood, quoted by Plaut,[21] states that he could not find any evidence, clinical or microscopic, in carcinoma of the lip that would allow one to conclude whether there is greater or lesser probability of metastasis. In Broders' original article[1] he cites 537 cases of squamous cell carcinoma of the lip, graded as follows:

Grade 1	15.8%
Grade 2	62.0%
Grade 3	21.0%
Grade 4	1.1%

Of 449 cases in which lymph nodes were studied metastasis occurred in 23.4 per cent and were absent in 76.6 per cent. Broders' Table 15 is reproduced here. It is interesting to note that there were no cases of Grade 1 with metastasis and no cases of Grade 4 in which metastasis did not occur. These two grades comprise but 16.9 per cent of all of his cases, the majority being Grade 2 and Grade 3. Without actually checking the accuracy of the

Fig. 2. Same case as in Figure 1, showing an adjacent area. Note smaller cells, disproportion in size of nucleus and cell; no keratinization, many mitoses.

statement to follow, it has been an interesting observation that wherever tumors are reported, Grade 2 is usually the predominating tumor. This is certainly so of my own studies and I wonder if the reason for this is not entirely a personal factor, a human factor. From what has been said of Broders' method, it is apparent that Grades 1 and 2 must merge together, while certain cases must lie between Grades 2 and 3 or are easily placed on one side or the other, and the same is true of borderline cases of Grades 3 and 4. The least malignant and the most malignant are easily decided upon but those that come in between are often hard to classify. This would not have any great significance if it were not for the statement of Broders himself, that since Grade 1 carcinomas of the lip do not tend to metastasize, it is not necessary to remove the glands of the neck, and since Grade 4 carcinomas of the lip are fatal sooner or later, radical dissection of the

Table 15
(Broders[1])

	Grade 1	Grade 2	Grade 3	Grade 4
Patient with metastasis:	0%	37.1%	60.0%	2.9%
Patient without metastasis:	19.5%	72.1%	8.4%	0%

neck offers no relief, but that in Grades 2 and 3, a considerable number of cures may be anticipated by surgical removal of nodes. This then places the responsibility for the removal of cervical lymph nodes upon the pathologist. If he calls the tumor Grade 1, these nodes may be disregarded unless metastases appear. If he calls the tumor Grade 2, the patient is exposed to extensive surgery. If it is important to remove these lymph nodes early, it would seem flimsy evidence on which to base so important a decision. Fortunately, it may make little difference, for roentgenologists have in recent years demonstrated their ability to control to some extent metastatic cervical carcinoma, and some prefer to withhold treatment until metastases make themselves apparent. If this is true, the grade of a tumor, further than to class it of low or high degree, is of no value. I leave out the question of radiosensitivity of highly undifferentiated cells for later consideration. It is noteworthy that Ochsner[19] in his discussion of a symposium on cancer of the lip at the Seventeenth Annual Meeting of the American Radium Society in 1932, states that 82 per cent of his cases were Grades 1 and 2 (Broders' series showed 78 per cent) and he thought all patients had a better chance with bilateral block dissection.

In a series of cases of lip carcinoma reported by Lund and Holton,[16] the importance is emphasized of size of lesion in relation to tumor grade. Broders pointed out in his early report that there were proportionately larger tumors in Grade 3 than in his lower grades. From his tables, one might consider that the small lesions were also early lesions and consequently have not as yet shown metastasis. Lund and Holton give a table of their cases which is listed below:

Size of Lesion:		Malignancy Grade	
Up to 1 cm.	46%	65%	1
1.1–2 cm.	36%	26%	2
2.1 or over	17.3%	9.2%	3

It is apparent that not all of the Grade 1 tumors were small or that all of the large tumors were Grade 3. In a study of his statistics on metastasis, we find 10 per cent of Grade 1 cases metastasized, but those that did had been present twice as long as those that did not. Time was evidently a factor. In Grade 2 about 20 per cent metastasized, but the duration of those that did was much longer than those that did not, except in the case of the larger lesions. In Grade 3, 43 per cent metastasized but those that did were of shorter duration than those that did not; therefore, it is reasonable to suppose that some Grade 3 tumors, in spite of their lacking differentiation, did not metastasize as early as others. The report of these authors reveals that while in a general way size is comparable with malignancy degree and the duration of the tumor, the coincidence is not sufficiently frequent to permit of dependence on any one factor in guiding prognosis or treatment. One may assume the same from Broders' tables. As a prognostic agent of probable length of life, the size of the lesion seems a better guide for cancer of the lip than histologic structures.

While in cancer of the lip, size and duration may be important factors, Rankin and Olson[23] believe the size is of little importance in the prognosis of tumors of the colon. In a general way, postoperative life and percentage of five year cures decrease as the grade of malignancy increases, but the differences are not great and the authors state that no uniformity exists when a single case is compared with others.

Cases with nodal involvement showed an incidence of 11, 55, 23, 11 per cent for Grades 1, 2, 3 and 4, respectively, and the percentage of five year cures was 47, 41, 15 and 25 per cent, respectively. In other words, in their series more than half of the cases showing metastasis were Grade 2, while Grade 2 cases as a whole showed five year cures almost as high as Grade 1 but not nearly so high a percentage of five year cures as Grades 1, 2, or 3 without lymph node involvement. The percentage

of five year cures without lymph node involvement was almost twice the percentage of five year cures with lymph node involvement.

Bowing and Fricke's study of 500 cases of rectal carcinoma[4] shows in a general way again the agreement of histologic grading with the probable length of life, but for the individual case there is little significance. They report 6 cases of Grades 1 and 2 papillary adenocarcinoma. Two died in less than one year; the remaining 4 lived one, four, seven and ten-plus years, respectively. What could one prophesy for an individual with Grade 1 or 2 papillary adenocarcinoma on such a basis? Again, 2 cases of 6 having a Grade 3 or 4 squamous cell carcinoma lived three and four years, respectively, while 2 cases of Grade 2 died in one year or less. The fact that more than half of their cases were in the inoperable (in the main extensive local lesions) or borderline group and 65 per cent of all cases failed to live longer than one year does not coincide well with the occurrence of 70 per cent of 220 cases graded falling in Grades 1 and 2.

Watson,[29] in a study of 267 cases of carcinoma of the esophagus, showed that the disease is of extremely short duration. All his patients died within eighteen months of the appearance of symptoms; epidermoid carcinoma, in less than one year. Cases graded 3 by Broders' method lived twelve months after the appearance of the symptoms, while Grade 1 cases lived only six months. In Watson's experience, adenocarcinomas grow more slowly and give symptoms earlier than squamous cell carcinoma. Whipple and Raiford[30] urge that all cases be studied clinically and pathologically by a combined group of physicians, surgeons, roentgenologists and pathologists. They call attention to the points emphasized above, that grading involves a personal factor inasmuch as it is not based on mathematical formulae and there are no hard and fast dividing lines. These factors include metastatic involvement in criteria determining the grade of malignancy. Gates and Warren[9] report a study of 5,052 cases of cancer in 4,987 patients. The authors comment that many tumors are fairly uniform, others vary, and they suggest the most malignant area upon which to base a grade. They think that changes in grade may occur in metastasis, but follow no regular rule for they were as frequently lower than the original tumor as higher. These authors in their summary express the opinion that grading of tumors should not be used as a guide in individual prognosis, but that in group prognosis and as an aid in estimating probable radiosensitivity the grade is of value. These authors found that histologic malignancy is independent of age or sex.

Location of the tumor is perhaps as important as any other one factor in determining the probable outcome of the case. We have just seen that carcinoma of the esophagus is rapidly fatal, regardless of the type of cell or the grade of malignancy or the size of the tumor when first seen. Tumors of the cervix uteri are also, by location, of a more serious nature than tumors of similar histologic structure in other areas.

Norris[18] found in a study of 20 cases graded as ripe (I), midripe (II), and unripe (III) that there was very little difference in the number of cases of each grade surviving five years and those that died within one year. Norris does not believe that histologic examination in his hands has been a practical or a reliable guide in either the prognosis or radiation dosage. Bowing and Fricke[3] conclude that adenocarcinoma of all four grades has a better survival rate than epithelioma. Cases of epithelioma Grades 3 and 4 had a better rate of survival than Grades 1 and 2, except after five years in cases that had been modified by previous treatment. Healy,[11] in a consideration of the cervix, mentions three cell types as three grades of malignancy. Twenty per cent of his cases were of the adult spinal variety (I), 60 per cent were transitional or midripe variety (II), 20 per cent were anaplastic or embryonal

cell tumors (111). He states that regardless of histologic structure early diagnosis is the most important factor in prognosis. Schmitz and Hueper[25] consider that cell differentiation alone is not a satisfactory guide as to the degree of malignancy. Hueper[13,14,25] considers the factors important in grading as occurring in four groups, (1) a special cell type, (2) the character of the cytoplasm, (3) of nuclei and (4) of stroma. By his own method his cases show a striking comparison between a histologic malignancy and end-results, but in his Table 3 the average indices of malignancy of what he calls Grades 1, 2, 3 and 4 lie too close to a general average to be of any great significance. These indices are obtained by considering 20 factors in the histologic structure, giving each value of from 1 to 4. The total of such numbers comprises the malignancy index.

AVERAGE MALIGNANCY INDEX FOR CERVIX (SCHMITZ AND HUEPER[25])

Patients symptom-free 3 years after treatment	52.45
Death in third year	53.00
Death in second year	60.00
Death in first year	61.00

It is interesting to note that in another communication Hueper,[13] in conclusion, states that the occurrence of carcinomas that do not obey this rule points to the extension of additional factors of a local and general nature which exert an influence on the growth of carcinoma and which cannot be evaluated by a histologic method. Perhaps the most comprehensive consideration of the recent literature on malignant tumors of the uterus is that of Gardner and Finola.[8] These authors state that the chief factor in determining the prognosis in any case of carcinoma of the cervix is the extent of local involvement. All other conditions are of secondary importance. Most gynecologists have accepted the clinical classification adopted by the Cancer Commission of the League of Nations. They further quote Kamniker as expressing the opinion of most gynecologists when he states that the prognosis depends upon the extent of the lesion rather than the histology of its component cells. Greenough and Taylor[10] and Simmons, Taylor and Wallace[26] compare the end-results of breast cancers in three groups of three years each from 1918 to 1926 inclusive, and it is rather striking in this table that better end-results were obtained in each succeeding three year period. In the first two three year periods they obtained no cure in Grade 3 carcinomas, while in the third three year period there were 50 per cent cures where the axilla was not involved and 23 per cent when the axilla was involved. Contrary to Gates and Warren, they believe that the end-results in the young are less favorable than in the older patients. Greenough and Taylor's[10] statistics for the 1921–1923 period show a definite relationship between cancer grade and postoperative duration of life. For the later periods reported by Simmons et al.,[26] the differences for Grade 2 and Grade 3 are not marked. These authors believe that though the grading of tumors is of value other factors must be taken into consideration.

Reimann[24] comments on the study of 100 patients; comparing his results of grading with the actual outcome of patients, he states that he was correct 6 times and incorrect 9 times in Class 1. In Class 2, he was correct 35 times and incorrect 31 times, while in Class 3 he was correct 9 times, incorrect 10 times. In the total average of all classes he was correct 50 times and incorrect 50 times. In checking upon his own judgment, Reimann permitted four experienced pathologists to review the same group of slides; the highest score was 57 per cent correct and 43 per cent incorrect guesses. Reimann admits that the number of cases in his series is too small for statistical analysis, and yet if one of his experience and knowledge of neoplastic diseases succeeds in making guesses that are but little better than might have

been made by pure chance, then histologic structure of breast tumors is not of value in prognosis.

Daland[5] studied 11 cases of untreated carcinomas of the breast which came to autopsy. In these he was unable to demonstrate a slower course in the lower grades of malignancy.

Many other reports of studies upon large and small series, either condemn or support tumor grading as a prognostic guide in cancer of the breast. Evidently the personal element does play an important rôle.

Pemberton and Dixon[20] found grading of thyroid tumors of some value. This has not been my experience, nor does the opinion seem to be a general one. Clinically malignant thyroid tumors often look harmless and malignant-appearing tumors in this gland sometimes fail to metastasize.

The effect of trauma to existing tumors, the physiologic state of the organ involved, such as cancer occurring in the breast during pregnancy, infection about the tumor, the vascularity of the tumor bed, all play an important rôle affecting prognosis. They are all self-evident and have been thoroughly discussed in publications listed in the bibliography.

Broders'[2] comment on cancer of the lip seems a fitting climax for what has been written: "Some epitheliomas of the lip from the start show little or no tendency to differentiate, some grow more malignant with time, and others increase in malignancy and then regress."

HISTOLOGIC GRADING OF TUMORS AND RADIOSENSITIVITY

When Broders first presented his method of grading neoplasms, it was for the purpose of revealing the probable duration of life and to indicate in which cases radical dissection of lymph nodes was advisable and which were totally inoperable. It was already known that highly anaplastic tumors responded more readily to radium and roentgen rays (Bergonié's law), so it is quite natural that the grades of tumors by this method would be quickly taken as an indication of radiosensitivity.

Experience has taught that there are many exceptions to this law. Malignant melanoma is perhaps the most outstanding exception. It is probably the relation of melanoma cells to nerve tissue (which is known to be resistant) that explains this exception. Basal cell epitheliomas are another well known exception, for though of low grade malignancy they are radiosensitive. The exception here is real for the cells of basal epitheliomas do not conform to the common understanding of highly anaplastic cells. More than this, Grade 4 carcinomas in different areas do not respond to the same degree of radiation. Norris[18] found the difference of radiosensitivity of cancers of the uterine cervix to be slight. Phillips, quoted by Hellwig,[12] could find no direct relationship between histologic character and response to irradiation in buccal carcinoma. Stewart, also quoted by Hellwig, found cancers of the oropharynx more sensitive than those located in the anterior portion of the buccal cavity, despite similar histologic structures. Quick[22] believes that the location of a growth has a great deal to do in determining from a physical standpoint the source of radiation and the type of applicator. The more adult types of growth call for greater intensity of treatment.

There are many contradictions in the literature concerning the relative radiosensitivity of adenocarcinoma and squamous cell carcinoma, but it is well known that lymphoid tumors are considerably less resistant than epithelial tumors.

Plaut admirably sums up the situation by his statement, "there is a bewildering mass of contradictions and misunderstandings in a matter of greatest practical importance." The situation is made worse by an apparent confusion of the terms radiosensitivity and radiocurability.

There are many factors that are as important as cell types, such as the location of the neoplasm and its accessibility. The character of the tumor bed and the vascu-

larity of the stroma play a rôle. Vascular papillary tumors respond readily when the delicate blood vessels are destroyed, despite relative maturity of cells. Density of stroma, the presence of fat, and severe infection have their effect upon the results of irradiation.

Stout[28] has considered many of these factors and has published tables showing the effect of each upon radiosensitivity. He shows, for example, that the presence of syphilis affects the sensitivity of oral cancer and that mucin secreting tumors are less sensitive than those of similar structures lacking mucin.

Desjardins[6] attacks the problem from the radiologist's standpoint. In his definition of radiosensitivity he emphasizes the importance of the quality of ray and the scheme of irradiation, declaring that these are as important as dosage in estimating the sensitiveness of cells. He has published a list of tumors in order of their comparative radiosensitivity. Ewing[7] offers a table in which the various factors influencing radiosensitivity are evaluated. If the difficulties herein described and the many misunderstandings of the present are to be avoided, it is necessary that the pathologist and radiologist, who are concerned with the diagnosis and treatment of neoplasms, learn a little of each other's problem, and by the adoption of a common language, understandable by both, they may anticipate greater success in the field of radiotherapy. Every pathologist and radiologist will find profit in becoming familiar with the recent publications of Ewing, Stout and Desjardins on radiosensitivity.

If pathologists will strive to accurately yet briefly describe the microscopic structures of tumors, and if radiologists and surgeons will carefully study such reports with the added benefit of consultation in the unusual cases, a much better understanding will result than can ever be hoped for from the histologic grading of tumors.

That histologic grading is of value in group prognosis and for statistical classification of tumors cannot be denied, but its inconsistency in the treatment or in the prognosis of the individual case has been established.

SUMMARY

The recent literature has been reviewed and discrepancies between tumor grades as a prognostic guide and actual outcome of cases reported have been pointed out. In many instances the authors of reported studies have themselves called attention to these discrepancies, though they have claimed that histologic grading was helpful in prognosis.

It has been demonstrated that histologic grading of tumors is of use in group prognosis and in determining the relative effect of age, sex and location of tumor upon malignancy.

The histologic grade of malignancy may give a clue as to the relative radiosensitivity of a tumor but here, too, there are pitfalls. The more reliable guides have been pointed out in publications by Ewing, Stout and Desjardins. Some of the many factors controlling radiosensitivity are discussed.

It is urged that pathologists and radiologists study one another's problems and by common agreement adopt the systems suggested by Ewing, Stout and Desjardins. By speaking a language both can understand, they may anticipate greater success and more rapid progress in radiotherapy than can ever be hoped for through histologic grading of tumors.

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DISCUSSION

DR. FRED W. STEWART, New York City. On several occasions, both at meetings of various radiological societies and in publication, I have tried to emphasize that personally I regard grading a method of group prognosis and not of individual prognosis. I have never seen any value in elaborate formulas of grading. The experienced pathologist has no difficulty in telling whether a tumor looks bad or not. If it falls in an intermediate group, where most lesions fall, one may have all sorts of chance accidents which may modify prognosis in the individual case. In any individual case of the average type the extent of disease outweighs everything else. No magical system of looking in a microscope will tell you what is to happen. The history will tell you much more than any microscopic examination.

As far as the question of radiosensitivity is concerned, there is a tendency to confuse tumor grade and sensitivity. I have always thought grading and radiosensitivity were different problems. As far as radiosensitivity is concerned, the thing Dr. Konzelmann *fails* to stress is the gradual acquirement from a large experience of an ability to predict responses by methods which involve reflections, mechanisms of thought, which are not easily expressible in words and formulas.

ERYSIPELAS CARCINOMATOSUM RESEMBLING RADIODERMATITIS*

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With Notes on the Histopathology

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THE title of this paper which I sent to the Program Committee was "Malignant Lymphangitis," but in searching the literature, I find that this disease has been described under "Erysipelas Carcinomatosum." Küttner first described this disease and reported 3 cases in 1924, under the above title. During the same year, Lee and Tannenbaum reported on 28 cases of "Inflammatory Carcinoma of the Breast," some of which undoubtedly belonged to this type of disease. Since then, I have found no record in American literature, but Freund and Knoflach, in 1934, state that 30 cases have been recorded in the German literature. Three types of malignant disease of the breast which particularly involve the skin have been described in the literature: first, cancer en cuirasse, first described by Velpeau; second, mastitis carcinomatosa first described by Volkmann and Billroth, and third, Paget's disease. It is thought by some of the authors that erysipelas carcinomatosum is a modification or type of Paget's disease. In fact, one of Nölle's cases, and 3 of my cases, began as Paget's disease.

Erysipelas carcinomatosum has in most cases followed operation for carcinoma of the breast, but in nearly as many cases has developed independently of operation. In a number of cases reported, the disease has followed postoperative irradiation, and in the very first case reported by Küttner, the condition was thought to be a radiodermatitis. In the last report in the literature, made in 1934 by Freund and Knoflach, as also in a number of my cases, the diagnosis of radiodermatitis or radiotelangiectasis had been made by others. It is therefore timely that we as radiologists take serious note of this condition. In a case reported by Rüder the disease seemed to follow a sun bath. However, since in most cases the disease develops independent of any local applications, it would seem that neither sun exposure nor irradiation has anything to do with the disease. It is important, however, for the good of the patient, for the purpose of obtaining correct treatment, and for personal protection of the radiologist, that we keep erysipelas carcinomatosum in mind.

Erysipelas carcinomatosum may begin entirely like a skin affection, either in the form of Paget's disease, or merely as a localized area of redness, and may then spread over one side or even both sides of the chest, and may spread downward over the abdomen, and up as far as the ears and backward as far as the spine. The disease may develop slowly, but generally develops rapidly so that from day to day progress can be noted, and in a case reported by Nölle, the left breast had already slowly developed an erysipelas carcinomatosum which had been diagnosed microscopically, and then the patient developed a chill, high fever, and the right breast became involved with an inflammatory process, which even under the circumstances was regarded as true infectious erysipelas until a biopsy proved it to be erysipelas carcinomatosum. The most characteristic feature of erysipelas carcinomatosum is the fact that it resembles erysipe-

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935. A portion of the material was presented as a preliminary report before the Philadelphia Roentgen Ray Society, April 4, 1935.

las most strikingly. The color is a flaming red; the borders are most irregular and often extend with finger-like projections but sharply defined, and the progress takes place in every way similar to erysipelas. Generally there are no chills or fever, but a moderate rise of temperature to about 100° F. is often found, but sometimes, as in a case reported by Nölle, the temperature may be very high, preceded by chill. The general condition of the patient during the early stages is usually good. There seems to be no constitutional effect, but, as the disease progresses, the patient's general health fails, and several cases terminated with pneumonia.

Generally at the beginning, no metastatic lymph nodes can be detected, but at times, palpable lymph nodes are the first symptoms, as in the case reported by Rüder. At the beginning, no tumor may be palpable in the breast, and the breast may not be enlarged. In the later stages, in unoperated cases, such enlargement and such tumor formation are usually present. The disease commonly extends to both breasts. In most of my cases both breasts had been involved by carcinoma or became involved, showing a great tendency to develop carcinoma. Generally, the disease seems to spread through the skin and subcutaneous tissue, and may involve one-half of the body before there are lymph nodes or evidence of metastasis. During months, the disease may be confined to the skin, and there may be no ulceration, but generally late and sometimes early, there are definite nodules developing in the skin and ulceration takes place. At autopsy, most of the organs of the body may be found involved. In the past, it would have been possible for an uninformed physician to make a diagnosis of radiodermatitis, and then to assume that the radiodermatitis was followed by the cancer which ultimately becomes plainly evident.

DIFFERENTIAL DIAGNOSIS

1. The disease can usually be differentiated clinically from radiodermatitis or radiotelangiectasis by the fact that it is not confined to the areas treated; the borders are irregular and jagged in outline, which is a condition that we never find in radiodermatitis. The central portion may become pale, and the edges progress. In the untreated cases, the pallor is probably due to complete blocking of the blood vessels by carcinoma cells while the reddened border is probably in great part due to the dilatation of the capillaries. In some of the cases, the disease seems to involve almost exclusively the blood vessels, while in others the lymphatics of the skin and subcutaneous tissue are definitely involved. In radiodermatitis desquamation of the surface skin ultimately takes place, or, in very severe dermatitis, a general ulceration may develop, but it is rather uniform in its distribution while in this disease, no desquamation of the epithelium is found, and ultimately very small nodules and localized ulcerated areas may be found which are simply a degeneration or necrosis of the rapidly growing subcutaneous cancerous nodules. The ultimate and final diagnosis, however, can be made by microscopical study of a section. The important matter in this connection is the fact that the attending physician must keep erysipelas carcinomatosum in mind, so as to think of taking a biopsy, for in true erysipelas a biopsy is not usually done.

2. The disease can be differentiated from erysipelas by the fact that in practically all instances it begins without chill and without fever. This disease, so far as we know, develops in the mammary region while erysipelas is very rare in the mammary region. There is less local heat, but the final and absolute differentiation must be made by means of the biopsy.

3. Erysipelas carcinomatosum differs from cancer en cuirasse in that it is not associated with the "pig skin" infiltration of the skin or a general scleroderma. It is possible, however, for this disease to develop into the definite form of cancer en cuirasse, as has been reported by Nölle, and as developed in one of my cases. In

FIG. 1. Case 1. June 25, 1923. Shows the erysipelas carcinomatosum involving the general operative field on both sides of the chest. Note the irregular outline and the fact that both breasts have been removed.

Nölle's case, bone metastasis took place, and the patient died approximately one and a half years after the disease began. Microscopically, it is thought that cancer en cuirasse extends particularly through the lymphatic channels, while erysipelas carcinomatosum extends particularly through the blood vessels or corpuscles of the skin by direct permeation.

4. It differs from mastitis carcinomatosa by the fact that the latter disease usually begins with an enlargement and marked tenderness of the breast, and occurs most commonly during pregnancy or lactation. Therefore, the attending physician very commonly looks upon mastitis carcinomatosa as an abscess, and commonly incises the tender diseased area, but obtains no pus. Lee and Tannenbaum say, "Almost without exception the lesions occurred in patients with pendulous breasts, and in 50 per cent of the cases, lactation had never occurred. The tumor involves the entire breast." Some of Lee and Tannenbaum's cases, reported under "Inflammatory Carcinoma of the Breast," seemed to resemble erysipelas carcinomatosum, and they add, "Some of these cases were supposed to have been produced by irradiation."

REPORT OF CASES

I have observed at least 15 of these cases, but I had indexed them under "malignant lymphangitis." Within the past two weeks, the photographs and records of another case have been sent to me by Dr. Will S. Judy, of Greenville, South Carolina. I will not report on all of these cases, but will refer only to the first and the last case.

The first patient was a woman, aged fifty-one, who was referred to me on January 13, 1922, by Dr. Desiderio Roman of Philadelphia. Her right breast had been amputated on April 12, 1918, by Dr. Roman, and the left breast November 9, 1921, also by Dr. Roman. Both showed microscopically "carcinoma simplex." It is a remarkable fact that this disease is very commonly associated with carcinoma of both breasts. When the patient was referred to me approximately three months after the second operation which involved the left breast, the patient had a thickened red scar, and at this time, when I first saw her, there was on the right side, where the operation had been done nearly four years previously, patches of induration, redness and vascular infiltration, which

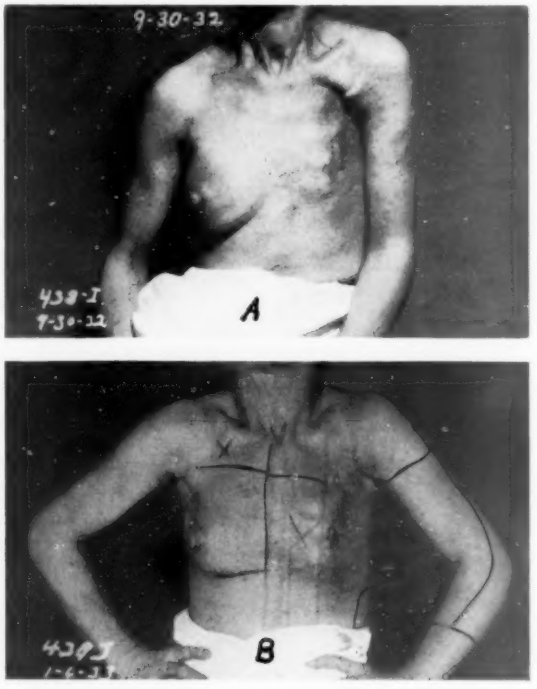

FIG. 2. Case XIII. *A*. September 30, 1932. Shows recurrent erysipelas carcinomatosum involving the entire left side of the chest wall, the epigastrium and the entire anterior and posterior surface of the left arm, extending down as far as the elbow. The latter areas were also involved by small nodules. *B*. January 6, 1933. Shows the disappearance of all of these lesions anteriorly.

were evidently due to erysipelas carcinomatosum, as is indicated by a later photograph (Fig. 1). The patient said that this redness followed an osteopathic treatment, which treatment was taken by her on account of pain. At the time she came to me, there were some increased shadows in the upper mediastinum which suggested possible malignant involvement, and there were also associated, at that time, enlarged lymph nodes in the supraclavicular region.

This redness disappeared temporarily as a result of the roentgen treatment, because even at the beginning, I looked upon it as a malignant process, but it recurred after considerable irradiation. The question then arose as to whether this might be due to the irradiation. In my opinion, it was not due to irradiation, and I showed the patient on February 28, 1924, before the Philadelphia Dermatological Society where the general opinion was that we were dealing with "lymphangioma circumscripta, probably malignant." A biopsy was recommended, and this was done April 1, 1924, by Dr. Roman. This biopsy was reported by Dr. Roman as being non-malignant, but it was probable that the irradiation which I had given had temporarily destroyed these malignant cells, for another biopsy done on October 31,1924, showed definitely adenocarcinoma. Following this second biopsy, the patient grew progressively worse. She became blind in the right eye, her mind became affected, and she died early in 1926, or approximately four years after she first came to me, eight years after the removal of the right breast, and four and a half years after the removal of the left breast.

The last case (Fig. 4) was a woman, aged forty-nine, who was referred to me on December 11, 1933, by Professor James M. Anders. Eight months previously she had noticed a tumor in her right axilla. This had gradually increased in size, and recently had become inflamed in appearance. Examination showed a carcinoma involving the tail of the right breast, located approximately 5 cm. below the apex of the axilla, and growing from the outer wall. It was nodular in appearance, and the skin showed a deep redness as if the tumor might soon ulcerate through the skin. There was some general thickening in the breast, but no actual tumor formation, and nothing that I could detect as evidence of carcinoma.

When the patient was referred to me on December 11, 1933, she also gave a history of

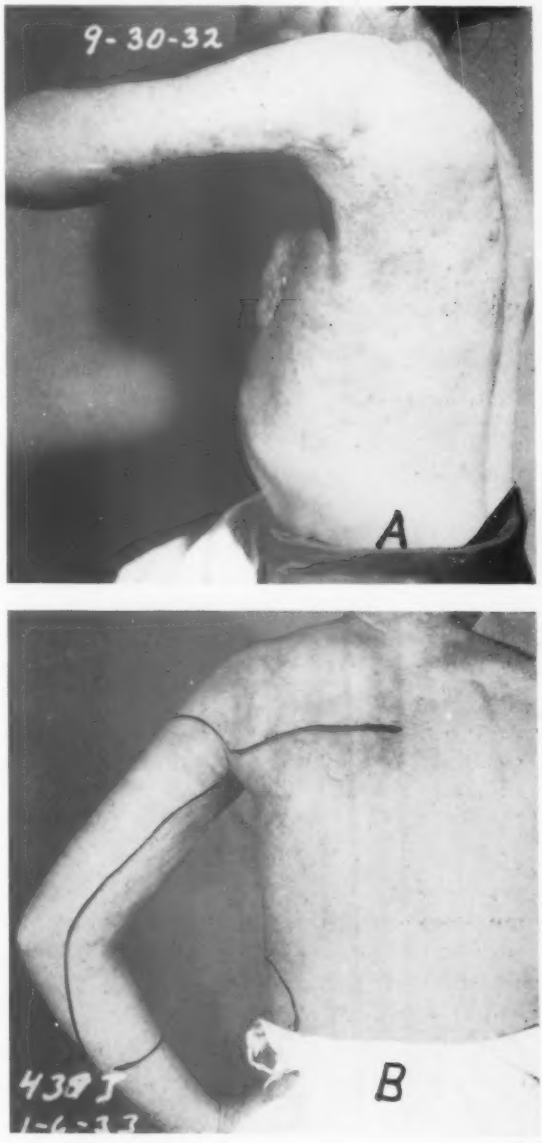

FIG. 3. Case XIII. *A*. September 30, 1932. Shows the extension of the erysipelas carcinomatosum over the left wall of the chest and back as far as the spine, also shows the contraction of the skin of the posterior surface of the arm, and is associated with multiple nodules. *B*. January 6, 1933. Shows complete disappearance of the disease as a result of irradiation. This patient came to the clinic on November 22, 1929, with inoperable carcinoma of the left breast. Later her right breast also became involved by carcinoma, and was treated by radium needles and roentgen radiation. She died of carcinoma September 11, 1933.

repeated excessive menstruation, lasting approximately nine days, and during April, 1933, she had a flooding spell. With the object,

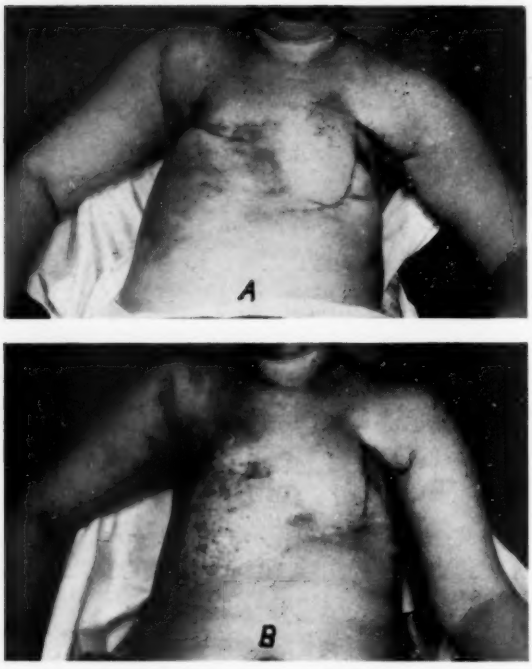

FIG. 4. Case XV. *A*. September 10, 1934. Shows the outlines of erysipelas carcinomatosum which was regarded as a radiodermatitis. It occupies the right mammary region, the upper abdominal region and extends across to the sternum, epigastrium and left mammary region. The microscopical section from the sternal area showed carcinoma. *B*. February 7, 1935. Shows the disappearance of the erysipelas carcinomatosum following roentgen treatment, but a new area of the disease involves the right shoulder and right arm.

therefore, of controlling the bleeding, and checking the anemia, and also reducing the hormone effect on the breasts, I advised a dilatation and curettage, and the introduction of radium into the uterus. On December 12, 1933, this was done by me, and 150 mg. of radium was inserted into the uterus, filtered through 2 mm. of platinum and 1 mm. of rubber, and left in place for thirty-four hours. This produced complete amenorrhea, and eliminated all pelvic symptoms. The microscopical report on the scrapings by Dr. Eugene A. Case was "chronic endocervicitis."

Roentgen examination of the right breast showed an infiltrating tumor having the characteristics of malignant disease, corresponding in location to the palpable tumor; there was no roentgen evidence of tumor formation in the breast. Roentgen examination of the chest, spine and pelvis showed no evidence of metastasis. On account of the advanced disease, I advised preoperative roentgen irradiation during the succeeding two weeks. Therefore 150 per cent of an erythema dose was given through each of four different areas during this time. Dr. Wm. Bates and Dr. J. B. Carnett did a radical operation for amputation of the breast on January 11, 1934. The patient recovered from this operation in a normal manner, and was referred to me for postoperative roentgen treatment on February 19, 1934.

On February 19, 20, 21, and 22, 1934, she was treated through each of three areas, using 100 per cent of an erythema dose over the supraclavicular, mammary and axillary regions. She was instructed to return for further treatment in one month. This she did not do. She reported for inspection to Dr. J. M. Anders in June, 1934, at which time he found no evidence of carcinoma. During July, in the absence of Dr. Anders and myself, she consulted Dr. J. B. Carnett, who found carcinoma of the *left* breast, and did a radical operation on the left side. She was not sent for any postoperative roentgen treatment of the left breast area following this operation. On September 10, 1934, Dr. Bates found recurrent carcinoma in the operative field on the *left* side, also a nodule in the *left* supraclavicular region. On account of the local recurrence, and the metastases, she was sent to me for roentgen treatment. At this time, I found recurrent carcinoma nodules in the *left* operative field, a nodule approximately 1.5 cm. in diameter, located above the *left* clavicle.

Over the entire right anterior chest, extending beyond the middle of the sternum and downward below the costal border into the right axilla there was found general deep redness very sharply defined, but irregular in outline, extending in a finger-like manner. These areas did not correspond to the area of previous treatment. There was a granular appearance, and no sensation so far as the patient was concerned. There was a small nodule in the apex of the right axilla. Both the patient and her husband said that this redness had been present since April, 1934, or approximately six months, and that it was thought to be due to the effects of the roentgen rays. I recognized it as a "malignant lymphangitis" (now I would call it erysipelas carcinomatosum) of the skin, a condition which I had found in a

number of previous cases in which there had also been made a mistaken diagnosis of radiodermatitis.

A biopsy of the skin overlying the middle of the sternum was made, and the specimen sent to Dr. Eugene Case, September 10, 1934, which showed a malignant lymphangitis. Immediate roentgen treatment was given over both mammary and supraclavicular and both axillary regions, 300 per cent S.E.D. was given over the mammary and axillary regions during a period of four days with 129 kv. at a distance of 40 cm. with 2 mm. Al filtration. On October 8, 1934, an additional 100 per cent S.E.D. was given over these two areas, with the result that a very marked desquamating radiodermatitis was produced, and this was followed by complete disappearance of the malignant lymphangitis. Similar treatment was given in the left mammary region while more penetrating rays were used in the coracoid and supraclavicular regions on both sides, using 200 kv., 45 cm. distance, and 0.5 mm. Cu filtration. In these areas, during this same period of time, we gave 150 per cent S.E.D. This was followed by complete disappearance of the superficial malignant disease. She had a total of 530 per cent S.E.D. in the left supraclavicular region, and the lymph nodes and nodular recurrences disappeared.

On December 11, 1934, three months after beginning treatment, another biopsy was done a few millimeters to the right of the previous biopsy which now showed no evidence of carcinoma. This second biopsy was taken from an area which had been just as definitely involved as the location of the previous biopsy. The disappearance of the malignant disease was undoubtedly due to the roentgen irradiation. On February 7, she developed a malignant lymphangitis (erysipelas carcinomatosum) on the inner surface of the *right* arm and this was given 300 per cent S.E.D. which was followed by desquamating radiodermatitis and disappearance of the disease.

On March 22, 1935, she developed an area of localized erysipelas carcinomatosum of the skin overlying the outer half of the *left* clavicle, covering an area about 6×3 cm. in diameter, and an area over the left mammary region, oval in shape, about 5×7 cm. in diameter. Each of these areas were given a local superficial dose of 200 per cent S.E.D., as previously described.

On March 22, 1935, she returned with no evidence of carcinoma; 300 per cent S.E.D. was then given beyond the lines of previous extensions with the hope of preventing further development. On April 17, 1935, she was also free from any evidence of disease.

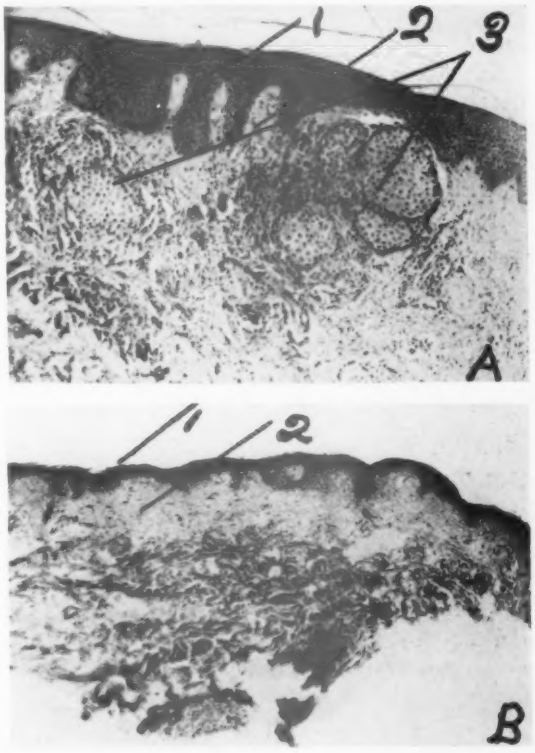

FIG. 5. Case XV. *A*. Section removed at the beginning of roentgen treatment to prove that this was not a radiodermatitis. Section shows the invasion of the corium by nests of cancer cells. 1. Epidermis. 2. Corium. 3. Cancer cells. *B*. Made three months after roentgen treatment. Complete absence of cancer cells in this section. There is an increase in the fibrous tissue of the corium. 1. Epidermis. 2. Corium.

On June 8, 1935, her husband reported to me by long distance telephone that the patient had developed a fever of 103.6° F. (axilla), pulse 140, respirations 32. The anterior portions of her left arm and hand were covered with white blisters, which looked like burns (no roentgen treatment had been given over these areas). She also had one spot on the upper part of her back between the shoulder blades. All of these spots appeared in the areas where she had used an electric heating pad for long periods; in fact, she had gone to sleep with it on her arm, hand, also on her shoulder. She was not

physically able to come to see me. In July, the husband reported that the patient was still confined to bed. Her left arm remained considerably swollen from the shoulder to the elbow, but the areas where the blisters had been present had completely healed. She died at her home on August 12, 1935, and I have not been able to get details as to the cause of death.

SUMMARY AND CONCLUSIONS

1. Fifteen cases of erysipelas carcinomatosum have been observed. Formerly this disease was considered by me as a malignant lymphangitis of the skin. The name has been changed to conform to similar cases described in the literature.

2. The disease has been reported upon since 1924. There are probably less than 50 previous cases recorded in literature.

3. The present report is concerned with the fact that the disease has been mistaken repeatedly for radiodermatitis or radiotelangiectasis.

4. The disease may develop like a lymphangitis of the skin or like an erysipelas.

5. In some cases the disease seems to extend through the blood vessels of the skin by direct permeation, but for the most part, it seems to extend through the lymphatics of the skin and subcutaneous tissue.

6. Radiologists and surgeons should become familiar with this disease so that it will not be mistaken for radiodermatitis, and that proper treatment can be undertaken.

7. The only treatment that seems to give definite improvement is thorough roentgen irradiation, but so far, no patient has been permanently cured.

NOTES ON THE HISTOPATHOLOGY

By Eugene A. Case, M.D.

Microscopical study of the biopsy material in these cases shows collections of cancer cells in the corium. The epidermis is not invaded but the groups of cells may encroach upon it and eventually destroy it in that location.

The cells are similar to those of the primary growth, atypical in character, with large rounded, deeply stained nuclei, and a moderate amount of cytoplasm. Degenerative and necrotic changes are not infrequent and the occasional mitoses indicate an abnormal growth rate.

The inflammatory changes are represented by a cellular infiltration of lymphocytes and monocytes, chiefly perivascular in distribution.

This picture is similar to that recorded in the literature, though our specimens did not show the marked dilatation of the capillaries there described nor did we find any cancer cells in the blood vessels as did Küttner, Lee and Tannenbaum, Rüder, and Rasch, who attributed the spread of the cells to a permeation through the blood vessels. In our specimens the groups of cells appear to be either in the tissue spaces or the lymphatics, a finding in agreement with the studies of Fischer, Brackertz, Mandl, Durst, Delbanco, Cemjachovsky and Bondarcuk, who were of the opinion that the spread of the tumor cells was by way of the lymphatics.

This permeation is not a cellular embolism which occurs when cells are swept from the primary tumor to regional lymph nodes, nor is it a growth through the tissue spaces, a method of local distribution of limited extent, but an actual growth through the lymph channels, especially in breast cases, along the deep fascia and from here up into the lymphatics of the skin, giving rise to the nodules observed in these patients.

Handley believes that lymphatic permeation is the chief means of cancer metastasis, not only in the skin but in other organs and tissues of the body, stating that cancer cells do not find a suitable medium for growth in the blood and are destroyed, except in the terminal stages of the disease.

There can be no doubt, however, that blood vessel permeation does occur in this condition, as shown in the reports from the literature previously mentioned.

From its clinical appearance, the process is distinctly inflammatory in character, but in the reported cases, no infecting organism

was isolated, and in our sections the picture was that of malignant disease with an inflammatory reaction, and not primarily an inflammation.

As previously mentioned, the picture is distinctly different from that of Paget's disease. The cellular character is dissimilar and the epidermis is primarily involved, not simply destroyed without invasion as in erysipelas carcinomatosum.

That disease may develop into cancer en cuirasse seems probable if sufficient destruction of the fascial lymphatics and plexuses with their contributing channels from the skin and subcutaneous tissue occurs, and it may be that treatment will delay or prevent its development.

The poor prognosis is supported morphologically by the widespread metastasis, making destruction of these far flung cells extremely difficult by the means at our command.

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DISCUSSION

Dr. A. W. Crane, Kalamazoo, Mich. I am very much interested in this presentation of Dr. Pfahler's because I think it is possible that there may be two conditions closely simulating each other, one, a true malignant lymphangitis, the other the malignancy following the application of the roentgen ray.

Some twelve or fifteen years ago, we had a patient with cancer of the breast, an elderly woman, too far advanced for the surgeon to undertake operation. After roentgen treatment, however, her condition improved so much that there was almost a cure, although not quite. There was a small area which the surgeon still thought was the seat of the disease. If he could remove that perhaps, he thought, he would completely rid the patient of the cancer. I advised him to wait two months, which he did, and then operated. While the patient was still in the hospital, he called me up and said, "There is a delayed x-ray burn which follows exactly the area you x-rayed." Naturally, I was much interested and visited the patient. We had used a protector with a square opening through it. Over the exact area that we had irradiated, there was a very red, thickened skin. I said, "That is certainly not an x-ray burn. I don't know what it is but I wish you would take samples from different places on this skin and have the pathologist examine it." This was done and the report stated a highly malignant carcinoma. After that I talked with various roentgenologists at the meetings and found that a few of them had seen something similar. From that time on we never have given a preoperative treatment. In some of these improved cases there would be a tragic recurrence after the operative procedure. The same thing is seen where needle implantations are made with radium. I came to the conclusion that it is inadvisable to have any area, which had been treated by x-rays, traumatized later by surgery or radium needles. I can't give a proper citation of cases because I had no idea of giving any talk on any such subject. I am simply raising the question, wondering whether any of the rest of you have had a similar experience and whether or not there ought to be a reconsideration of preoperative irradiation.

Dr. Pfahler (closing). I appreciate these questions. It is not surprising. First of all, over half of the cases that are reported in the literature had no irradiation when this disease

developed. There have been about 30 such cases that have been collected and reported in Europe and there are a number of cases reported by Dr. Lee and Dr. Tannenbaum in this country. These authors did not clearly separate those cases in their report. There are probably about 50 cases on record. There must be ten times that many or more in the experience of radiologists, surgeons and dermatologists. Most of these cases have been previously reported by dermatologists. There is one case on record in which the disease followed a sunburn. A patient was taking a sunbath and the disease developed shortly after that sunburn. That would raise the question that perhaps additional irritation might be the cause, but in all of these cases that have been reported or studied by others or studied by me, we had a very advanced disease with skin involvement of some kind at the beginning and Dr. Crane speaks of an inoperable case with which he started.

We know too that many cases are operated on today that would be considered inoperable if they were not expected to be controlled by irradiation at a later date. As I say, half of the cases (I didn't count them, but it is approximately half) had no irradiation when this disease developed. I believe that the irradiation has nothing to do with it at all.

In the first case I showed, the patient had been operated on the right side, yet this disease developed on the left side the same as it did on the right. I believe the irradiation did not cause it. As has been proved by the pathological slides which Dr. Case showed to you and which he discussed, there is no question but that we caused a complete disappearance of the disease as a result of the irradiation which I had given. I believe if these cases are treated widely enough beyond the visible or palpable disease that we probably can arrest the disease. I never had a chance to do this. This patient from whom biopsies were taken before and after treatment was one of those who got very sick every time I treated her, and it didn't matter how big or how small a dose I gave.

One of the surgeons who made a report on this subject, has said, "If you want to operate on these cases, you must go at least 10 cm. beyond the area of the disease. On a case that had been operated on, it was found malignant cells extended 3 cm. beyond the border of the recognizable clinical disease.

Vol. 35, No. 6

HYPERTENSION AND DIABETES: THEIR TREATMENT BY RADIOTHERAPY*

By JAMES H. HUTTON, M.D.
CHICAGO, ILLINOIS

THE evidence that essential hypertension is due to abnormal function of the pituitary or the adrenals or both is voluminous and is being enlarged constantly. The relation of these two structures to diabetes mellitus is being intensively studied by many investigators who are collecting a great deal of evidence pointing to the importance of these two glands in carbohydrate metabolism. It seems fairly certain that diabetes mellitus is due in part at least—in my opinion, in most cases very largely—to some abnormality of function of the pituitary or the adrenals or both. It can be safely asserted that no further progress in the handling of this disease will come about until we cease to focus our attention entirely on the pancreas as the cause of this disorder.

We would do well to examine occasionally the terms we use in discussing various syndromes to find out whether these terms indicate knowledge or the frontiers of ignorance. We talk glibly of hyperthyroidism, but there is considerable doubt whether this syndrome is really due to a disease of the thyroid. Evidence that it is not is constantly increasing. The very term "essential hypertension" shows our ignorance of its etiology. Most of our treatment has been as ineffective as our knowledge is vague.

The resemblance between diabetes mellitus and Graves' disease is closer than is usually realized. This is brought out in Table 1 taken from Eason.[4]

There is considerable evidence that diabetes mellitus and essential hypertension resemble each other or are related to each other more closely than is generally thought. Perhaps two-thirds of our cases of essential hypertension exhibited a diabetic type of sugar curve. Arteriosclerosis is a common complication of both conditions. More diabetics die from cardiovascular disease than from any other cause.[5] In this respect also they resemble the victims of essential hypertension.

BASIS FOR WORK DONE

For some years I have been convinced that essential hypertension is due to some dysfunction, probably in the nature of an overactivity, of the pituitary and/or the adrenals. It is quite likely that when one departs from the straight and narrow path of normal function, the other shortly follows. It was believed that the well-known inhibiting effect of the roentgen ray on glandular function could be used to advantage in the treatment of diabetes mellitus and essential hypertension.

We have been working along this line for something over two years. During this time there have been treated, either under my supervision or in laboratories to whose

TABLE 1

Exophthalmic Goitre		Diabetes Mellitus
+ during absorption, sometimes post-absorption	Hyperglycemia	+
Intermittent	Glycosuria	+
+	Emaciation	+
+	Excessive appetite	++
+	Conversion of fat and proteins to glycogen and glucose, causing acidosis	+
+	Nitrogen excretion	+
Low	Respiratory quotient	Low
Excessive	Sugar mobilisation	Excessive
Defective	Sugar conversion to fat and glycogen	Defective

* Read before the Illinois Radiological Society, Bloomington, Ill., April 28, 1935.

records I have access, 157 cases of hypertension. Of these, 96 were improved, 24 unimproved, 28 had insufficient treatment and 9 could not be followed. During the same period 18 patients who were victims of diabetes mellitus and essential hypertension have been treated. Of these, 7 were improved as to both conditions, 4 as to their hypertension, 3 as to their diabetes, 3 had insufficient treatment and 1 could not be followed. Forty-five cases of diabetes without hypertension have been treated. Of these, 20 were improved, 12 were not improved, 11 had insufficient treatment and 2 could not be followed. In this connection we use the word "improved" to indicate patients who exhibited a notable increase in carbohydrate tolerance. This is indicated by their ability either to take a more liberal diet without glycosuria or hyperglycemia, or to reduce their insulin on a liberal diet or dispense with insulin without further restricting their diet.

Dr. Barnes[1] has reported the treatment of a number of pancreatectomized dogs. He was able to reduce the insulin requirement of these totally diabetic dogs by from 50 to 65 per cent by small series of low dosage roentgen treatments directed to the pituitary or the adrenals. This work is still in progress. Many of its problems have not yet been solved, but one thing is certain and that is that the good accomplished by the roentgen ray is done with small doses. Heavy doses not only do not increase the effectiveness of the radiation but actually aggravate the diabetes. Essentially the same statement might be applied to the treatment of essential hypertension or of the two conditions combined, so that while we do not claim to have determined the optimum dose of the roentgen rays, we have demonstrated, to our own satisfaction at least, that whatever good can be accomplished by the use of radiotherapy is done with small doses.

INDICATIONS

We have not yet been able to determine which diabetic is apt to respond favorably to the treatment and which is not. We are on firmer ground when it comes to hypertension or to hypertension and diabetes combined. Regarding the latter combination, it can be stated that, so far as our small experience goes, any patient who is a victim of both conditions has more than an even chance of being relieved of one condition or the other by roentgen therapy carefully administered and thoughtfully controlled.

When this work was begun there was no thought of applying this form of therapy to hypertension due to or associated with nephritis. However, for various reasons a number of nephritic patients with hypertension have been subjected to this form of therapy with more than symptomatic relief in a few cases. Some years ago Goldzieher[6] expressed the opinion that "primary renal hypertension might change into or combine with essential hypertension." My feeling is that he is probably correct.

Before treatment is undertaken the patient should be carefully studied. If this study shows marked evidence of arteriosclerosis, the outlook is not so good as when sclerosis is not present. Stieglitz' amyl nitrite test, we believe, offers some measure of the reduction in blood pressure that may reasonably be expected to follow irradiation of the pituitary and adrenals. Most patients are subjected to this test.

O'Hare[9] suggested that the glucose tolerance test might be used to separate the nephritic from the non-nephritic type of hypertension. Those exhibiting a diabetic type of sugar curve he felt belonged in the essential group. We have performed 62 glucose tolerance tests on 60 patients. Forty of these patients showed a diabetic type of curve and in 28 of these the blood sugar rose to 200 or above. Very few of these patients exhibited any glycosuria during the test. If this high renal threshold is an indication of renal damage, it is the only indication that could be found. About two-thirds of the patients exhibiting a diabetic type of sugar curve showed material improvement following roentgen therapy.

We frequently determine the basal metabolic rate. It usually does not vary significantly either above or below normal; but in 2 cases the usual signs and symptoms of Graves' disease were present, including marked elevation of the basal metabolic rate. These are reported in detail later in this article.

	Kv.	Portal	Filter	Skin Target Distance	Ma.	Time	Ma-Min.	Roentgens
Pituitary	120	10×10 cm.	2 mm. Al	50 cm.	5	7 min.	35	76
Adrenals	120	15×15 cm.	2 mm. Al	50 cm.	5	7 min.	35	76

In most cases we determine the nonprotein nitrogen, urea, uric acid, calcium and cholesterol in the blood. If a high cholesterol and a low basal metabolic rate are found in the same patient, thyroid is administered in sufficient quantities to bring the basal rate up to normal or to cause an increase in pulse rate to slightly above normal, unless its use produces unpleasant symptoms, such as nervousness, heart consciousness or extrasystoles. Occasionally patients exhibit a low blood calcium. These are usually given some form of calcium medication by mouth. The nonprotein nitrogen, urea and uric acid are practically always within the range of normal.

TREATMENT

From time to time we have used various factors in the roentgen treatment of these patients. We first used the following technique:

	Kv.	Portal	Filter	Skin Target Distance	Ma.	Time	Ma-Min.
Pituitary	110	10×10 cm.	1 mm. Al 0.25 mm Cu	50 cm.	4	20 min.	80
Adrenals	Same dosage in every respect.						

The dosage was gradually stepped up and in a few cases we used the following factors:

	Kv.	Portal	Filter	Skin Target Distance	Ma.	Time	Ma-Min.	Roentgens
Pituitary	180	10×10 cm.	1 mm. Al 0.25 mm. Cu	50 cm.	5	15 min.	75	142.5
Adrenals	180	15×15 cm.	1 mm. Al 0.25 mm. Cu	50 cm.	5	20 min.	100	190.0

This treatment was followed in every case by some unpleasant reactions, such as headache, vertigo or undue exhaustion. The blood pressure did not decline after treatment with these factors. As previously mentioned, we are now convinced that small doses are safer and more effective than heavy doses. We now use:

At the present time the only variation is to increase the time factor in heavy patients. Both sides of the pituitary and the adrenals are treated at the same time, the pituitary through a 10×10 cm. portal and both adrenals through the common 15×15 cm. portal.

In the beginning treatments were given at intervals of once a week until a series of six had been given, unless the blood pressure was satisfactorily reduced by fewer treatments. I am convinced that the response of the blood pressure is the best indicator for repeating the treatment. Frequently the first treatment is followed by a very marked reduction in blood pressure and relief of symptoms. In such cases no further treatment should be given until the blood pressure rises appreciably or there is some recurrence of symptoms. Too frequent repetition of treatments where the blood pressure has shown a marked fall not only does no good but in some instances aggravates the symptoms and is followed by a rise in blood pressure. The explanation for this is unknown to me. Barnes[2] finds

that in totally diabetic dogs the increase in carbohydrate tolerance following one treatment is temporary, but if three treatments are given at intervals of three to seven days, this gain in tolerance becomes permanent. Even if the pressure is not reduced at the end of a series of six treatments, the patient is allowed to go without further treatment for a month or six weeks when the series is repeated.

RESPONSE TO TREATMENT

As just indicated, many patients exhibit a marked fall in blood pressure and almost complete symptomatic relief after the first roentgen treatment. Others exhibit little or no decline in pressure until after three or four treatments are given, when there may be a rapid decline in pressure to nearly normal levels. Others experience a slow but rather steady drop in pressure under treatment. Some patients show a prompt reduction in diastolic pressure to almost or quite normal levels with a much less marked reduction in their systolic pressure. In other patients the most marked effect is on the systolic pressure while the diastolic at first shows little response to treatment. In most cases no attempt is made to bring the blood pressure to theoretically normal levels in those patients who have known of their hypertension for several years or in whom there is an appreciable degree of arteriosclerosis.

There is some dissociation between the hypertension and the patient's symptoms. In some cases the blood pressure is reduced to satisfactory levels and symptoms are entirely relieved. If the patient discontinues treatment, there may be a considerable rise in blood pressure without return of symptoms. In other cases, there is considerable symptomatic relief without a commensurate reduction in blood pressure. The explanation for this is likewise a mystery to us.

BY-EFFECTS OF TREATMENT

Certain interesting and entirely unexpected phenomena have been observed following these treatments. More than 50 per cent of the patients expressed themselves as being more clear-headed, able to work more easily and to better advantage. Practically all patients claim an increased amount of physical endurance. Three out of 4 say that they experience a curious relief of tension, that they are less irritable and are able to relax as never before. There is a tendency for the skin to become smoother and moister. This has been noted particularly in patients who had been troubled with dry skin and with brittle nails.

In a few cases some sexual rejuvenation or revivification has been claimed, and male patients set up certain standards by which they claim to measure this change. Menstrual irregularities, particularly menorrhagia and dysmenorrhea, are corrected. These changes, of course, are in line with those reported by Drips and Ford.[3] Hofbauer[7] in 1922 began using the roentgen ray in the treatment of menopausal disturbances. There is good evidence for believing that the vasomotor phenomena, the hot flashes, the sweating and the symptoms of "hyperthyroidism" are due to a disordered function of the pituitary and adrenals occurring as a result of the withdrawal of the ovarian function. At any rate, women who had hypertension and were also troubled by menopausal disturbances claim marked relief of the latter following this treatment.

CASE HISTORIES

A woman, aged forty-six had a blood pressure of 170/100. She complained of nervousness, insomnia, and lack of endurance. Pulse rate was 100 and the basal metabolic rate was plus 48 per cent. The administration of Lugol's solution did not relieve any of the symptoms nor affect the blood pressure. After three roentgen treatments to the pituitary and adrenals she was symptom-free. The blood pressure declined to 135/80 and the basal metabolic rate dropped to minus 6 per cent.

A woman, aged fifty-nine, had undergone one subtotal thyroidectomy in 1928 and another in 1929. A third operation had been rec-

ommended when I saw her in 1934. She had a small nodule in the thyroid, had lost 20 pounds in the previous six months, and presented the usual signs of hyperthyroidism. Pulse 120, basal metabolic rate plus 56 per cent, blood pressure 205/75. After six roentgen treatments to the pituitary and adrenals the blood pressure was 135/88, pulse 88. The symptoms of hyperthyroidism had disappeared and the basal metabolic rate was plus 18 per cent.

Dr. J. V. Fowler told me of a case that had the usual signs of Graves' disease including an elevation of the basal metabolic rate. Over a period of years he underwent three thyroid operations and shortly after the third, as after each of the other two, he exhibited the usual signs of Graves' disease in the same severity as existed prior to operation. His symptoms were partially controlled by Lugol's solution but not to the extent that he was able to return to work. He was referred to Dr. Culpepper for roentgen treatment of the pituitary and adrenals. Following these treatments his symptoms disappeared and he shortly returned to work.

CONCLUSIONS

This work has been in progress for over two and a half years, but use of roentgen radiation for the treatment of essential hypertension has been done, in most instances spasmodically, for more than twenty years. Dr. Martin[8] has treated about 100 individuals over the past thirteen years and says that in about 80 per cent the treatment reduced the blood pressure, with no bad effect. His treatment was given primarily for infected tonsils. Our experience indicates that this form of therapy affords considerable relief of symptoms with coincident reduction of blood pressure to safer levels in a considerable number of cases of essential hypertension. Whether these effects are permanent cannot yet be determined. In the hands of an experienced clinician and a careful roentgenologist this form of therapy is without danger.

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AN IMPROVED HIGH VOLTAGE ROENTGEN-RAY TUBE*

By BENEDICT CASSEN, Ph.D., *and* K. E. CORRIGAN, Ph.D.
DETROIT, MICHIGAN

IN A previous publication from this Department,[1] an attempt was made to outline the present state of development of so-called "supervoltage" roentgen tubes suitable for medical treatment purposes; to show some of the problems confronting the roentgenologist and physicist in putting one of these tubes to practical use in a hospital; and to indicate a few lines along which further development was desired. Both the advantages and disadvantages of the center ground and end group constructions that had been built or projected at that time were considered. In this paper we shall try to avoid all repetition of these considerations, and discuss an improved center ground tube which combines all the major advantages of both the center ground and end ground tubes of conventional type.

In general, there are six major points which must be considered in choosing a type of supervoltage tube, and the best design for any given installation is usually arrived at by compromise among these various limitations. In general, these are: (1) possible disposition of patients or absorbing material around the target, (2) roentgen-ray protection, (3) electrical clearances, (4) volume and size of the roentgen tube, and the ease with which its central parts can be reached, (5) expense and (6) space requirements.

It is obvious that the end ground tube for supervoltage work has a disadvantage in that its power plant must be built and insulated for the full voltage, making an expensive construction and requiring a large space. On the other hand, the advantages inherent in having the target at ground potential and enclosed in the treatment room so far outweigh this limitation that all of the supervoltage tubes in operation in hospitals at this time are of the end ground construction. More importantly, only one machine room is required, while in any center ground arrangement built or projected to date, essentially two machine rooms or one enormous room built around the treatment room are required.

The tube described in this paper was developed for the production of a high intensity source of neutrons for research work with the artificially radioactive substance produced by absorption of slow neutrons. For this work, the requirements are largely the same as for a roentgen-ray tube but the problem of surrounding the target with absorbing material is of even greater importance. In the first place, it is of great importance that as few of the neutrons as possible be lost; in the second place, nothing is known of the physiological activity of neutrons although it is believed that they produce blood changes and will kill experimental animals; hence, in order to operate the tube in the laboratory, it was essential that the protective material eliminate all stray radiation.

TUBE CONSTRUCTION

The details of the construction of this tube are to be published elsewhere; the general lay-out showing how the stated requirements were met is shown in Figures 1 and 2.

Figure 1 is a longitudinal section diagram of the tube showing its internal construction. The body, which is grounded, is steel, acetylene welded together. The two porcelain high voltage arms consist of ordinary transformer bushings readily available on the market. The target is enclosed in a small side-arm extension on the main body of the tube. The bottom end of this arm is readily removable, and through this open-

[1] Leucutia, T., and Corrigan, K. E. Present status of roentgen therapy with voltages above 200 kv.; technical development and medical application. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 628–662.

* From the Research Division, Department of Roentgenology (Dr. William A. Evans, Director) Harper Hospital, Detroit, Mich.

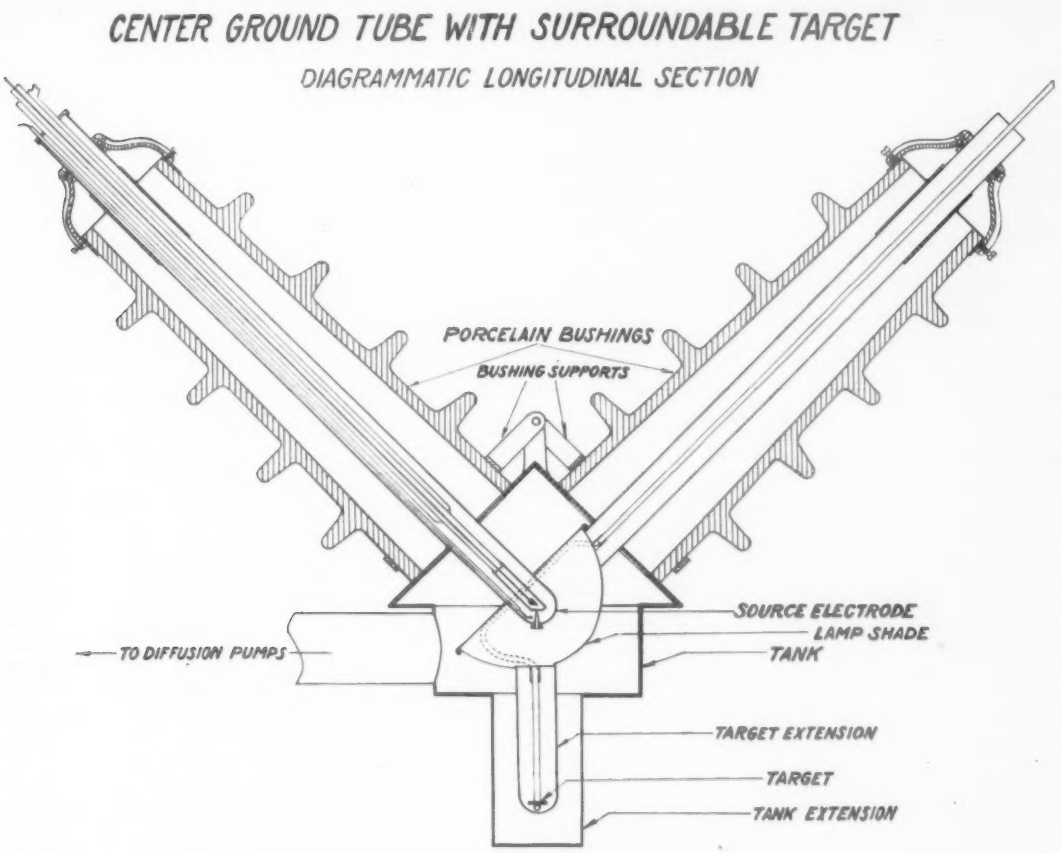

Fig. 1

ing the target can readily be removed and replaced. The "source electrode" serves as anode when the tube is utilized for the production of neutrons, and as cathode when used for the production of roentgen rays. It is easily removed through its own guide at the top of the bushing.

Arrangement as a Neutron Tube

Figure 2 shows the experimental tube installed in the laboratory for the production of neutrons by the bombardment of lithium deuteride by deuterons. This tube has been operated up to 300 kv. In this installation, the tank extension points downward so that it may be almost entirely surrounded by material for slowing down the emergent neutrons, and this layer of material may have immersed in it the substance in which it is desired to absorb the slow neutrons. The material used for protection, in this case sheet cadmium, goes outside of this layer. It is worth notice that the protecting material can surround the target except at the point where the tank extension joins the body of the tube. On account of this fact, all but about 10 per cent of the radiation from the target can be absorbed in material surrounding it. A small angular range of the radiation is not surrounded, and

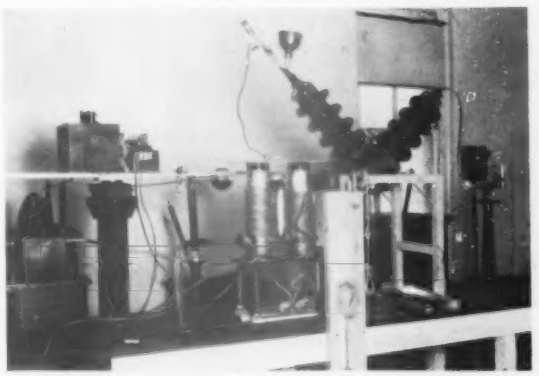

Fig. 2

radiates through the body of the tube. This is a very much smaller angle than that open to the "stem radiation" from an ordinary end ground tube, and since there is no electrode extending out from, or near, this point, it is a very simple matter to block off this radiation by covering the top of the tube body with absorbing material.

ARRANGEMENT AS A ROENTGEN TUBE

The tube is converted to a roentgen tube by simply replacing the positive ion arc shown in the diagram with a conventional filament and focusing cup. In this form the tube, since it can be operated in any position, horizontally or vertically, up or down, could be introduced into a treatment room through the floor, ceiling or side wall, to give the roentgenologist the optimum arrangement for his patients. For example, with the tube projecting through the ceiling into the treatment room, four portals could be used in a horizontal plane and one vertical downward onto a treatment table. In the same manner, with the tube projecting upward through the floor, four horizontal portals could again be arranged, with a fifth portal again projecting through a treatment couch. The protection problem has already been covered, but we may point out that complete roentgen-ray protection can be obtained with a minimum of lead, and that the usual troublesome beam of "stem radiation" can be completely eliminated. For such use the target is of the transparent type already in routine use in this and other institutions.

As already stated, the tube shown is built for an operating potential of 300 kv., and a maximum potential of 450 kv. By increasing the size of the component parts potentials up to 1,000 kv. could be handled conveniently by the same construction, in which case clearances would be required for only 500 kv. The tube can be installed in a minimum of space and advantage can be taken of space available in existing hospital buildings.

To the practical roentgenologist, it is of the utmost importance that a tube be quickly and easily repairable, and that it have as small a volume and as fast a pumping system as possible. When a filament burns out in a modern supervoltage plant, it is necessary to replace it and get the tube back in operation with the least possible delay. With the systems now in use, it is usually possible to replace a filament in about the same time that is required to replace a sealed tube in an oil drum. The actual cost of such replacement is, of course, negligible compared with the cost of replacing a sealed tube. In the tube described, this operation is very easy, and as the volume of the tube is small in comparison with the supervoltage tubes now in use, an operating vacuum can be regained in a very short time. The tube, of course, is operated on apiezon oil pumps.

A disadvantage of this type of tube over the end ground construction is that a water cooling system is required to operate at high voltage. Again the fact that the total voltage on the tube is divided, simplified this difficulty, and for voltages up to 1,000 kv. the usual type of pump and reservoir, driven by an electric motor through an insulated shaft or belt, is entirely suitable. In the installation shown, the pump is belt driven.

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Twenty-second Annual Meeting, 1937: To be announced.

EDITORIALS

CHOLANGIOGRAPHY

THOSE of us who were medical students some twenty years ago will recall with considerable interest the discussions which our surgical professors gave concerning the value of cholecystectomy versus cholecystostomy and the reasons advanced for the more conservative type of operation in gallbladder diseases. This was before the day when the roentgen ray was used routinely as a method of examination and preceded by a number of years Graham's great contribution to the diagnosis of gallbladder disease. During these twenty years, both as a result of surgical treatment of biliary diseases and the experience gained therefrom and the information obtained from the Graham-Cole method of examination, the surgical diagnosis and treatment of gallbladder disease has advanced remarkably. Allen[1] tells us that the pioneers of modern surgery were content to do a cholecystostomy to remove the stones within the gallbladder and that surgical exploration of the biliary ducts was resorted to only in the presence of prolonged jaundice or when a large stone could be palpated within the duct or, secondarily, when symptoms persisted after cholecystectomy, and that the older surgeons were content to leave the ducts unexplored even in the presence of mild or moderate jaundice in the hope that this feature of the process was due to a secondary inflammation about the duct rather than to the presence of a stone within it. The great number of cases that failed to obtain complete relief from the simple procedure of cholecystostomy prompted the surgeons to a more careful surgical exploration of the ducts in the hope that a greater percentage of cures might be obtained. But the surgical exploration of the ducts, except in the hands of the most capable surgeons, is fraught with considerable technical difficulty and with an added danger to the patient from this operative procedure.

Allen states that roughly the symptoms and signs which cause one to suspect a pathological condition within the common or hepatic ducts may be divided into two main groups: the preoperative and the operative. Among the preoperative signs and symptoms are jaundice, continuation or recurrence of symptoms after biliary tract surgery, chills and fever following epigastric pain, frequent attacks of biliary colic, severe nausea associated with attacks of typical pain, and gallstones found in the stools before operation. Among the operative signs and symptoms are small stones or sand within the gallbladder, palpable stones within the ducts, contracted gallbladder, dilated cystic duct, dilated common duct, thickening in the head of the pancreas, gallbladder without stones and cholangitis. From this it is evident that exploration of the bile ducts is performed largely on indirect evidence and the correct interpretation of this evidence depends on the experience and diagnostic skill of the individual surgeon, and that the good results obtained from such operations are in direct proportion to the ability and the skill of the surgeon. Not infrequently when a skillful surgeon explored the common duct he could not be certain whether the supposed obstruction had been completely removed. This is quite easily understood when one takes into consideration the various anatomical abnormalities that may be present in the cystic and common duct and in some cases the cause of the obstruction is not recognized, the presence of a stone being assumed when stricture or tumor is present, and not infrequently the

[1] Allen, A. W. The diagnosis and treatment of stones in the common bile duct. *Surg., Gynec. & Obst.*, Feb. 15, 1936, *62*, 347–357.

failure to secure the supposed stone is explained on the basis that it has been pushed through the ampulla into the duodenum. Later, after the removal of the gallbladder, the true condition of the patient finally becomes apparent and opportunity for sidetracking the bile by doing a cholecystoduodenostomy has been lost.

It is in these doubtful cases that cholangiography is of such a tremendous aid. Various writers from time to time have called attention to the importance of determining the patency of the common duct. As early as 1927 Piccinino and Pazienza[2] reported the results of the injection of radiopaque substances into external biliary fistulas and were able to show that the complications of biliary tract surgery could be satisfactorily studied in this manner. Numerous writers since that time have made contributions to the subject. In 1932 and in 1936 Mirizzi[3,4] made important contributions to this subject and added a great deal to its development when he reported successful visualization of the biliary ducts while the patient was on the operating table and after the common duct had been opened. This author advocated in 1936 that in these cases of common duct obstruction cholangiography be performed during the actual operation by injection of lipiodol into the gallbladder to exactly determine the nature of the obstruction and by this simple procedure would be obviated subsequent operations for obstructions which were overlooked at the time of the initial operation. He emphasized the fact that it had become the custom in most places to inject the biliary fistula postoperatively, but that few if any besides himself followed the procedure of injecting the ducts with an opaque medium at the time of the first operation which would definitely outline the surgical technique so as to forestall any later complications. He pointed out that when there is anatomic obstruction, as for example, a very small stone in the Heister valve or concentrated bile in the cystic duct, the opaque oil injected into the gallbladder would fail to pass into the duodenum. By this method of examination Mirizzi was able to determine before the abdomen was closed whether or not the ducts had been completely freed of stones.

Mirizzi's method of examination was fairly simple but more recently Robins and Hermanson[5] have still further simplified the technique of cholangiography by substituting hippuran for lipiodol and they have injected the opaque medium before the duct is disturbed. They use a metal tunnel similar to a curved Potter-Bucky diaphragm without a grid, equipped with a sliding drawer, which is placed on the operating table so that it lies under the patient's back. This tunnel is so arranged that the drawer opens on the side of the table where the assistant stands. A 14″ by 17″ double screen cassette loaded with a 14″ by 17″ film is placed in the drawer. The patient is then placed on the table so that the regions of the liver and biliary passages are in the field of exposure. Anesthesia is induced, and the operative field is prepared in the usual manner. The towels blocking the field and the skin towels for protecting the wound are stitched in place or held with aluminum clips in order to prevent metal shadows from appearing on the film. The operation is conducted as usual except that the common duct is identified before the gallbladder is disturbed. The cystic duct is then carefully dissected and clamped. By means of an ordinary 30 cubic centimeter glass syringe and a 15 to 18 gauge angulated tonsil needle 20 to 25 cubic centimeters of hippuran is then injected into the common duct. A towel is placed over the wound; the operator and assistants step aside; a portable roentgen-ray unit is brought into position; and an exposure is made. The

[2] Piccinino, G., and Pazienza, M. Quoted by Robins and Hermanson.

[3] Mirizzi, P. L. Quoted by Robins and Hermanson.

[4] Mirizzi, P. L. Diagnosis of incomplete non-calculous obstruction of the choledochus; their treatment by cystico-duodenostomy. *Presse méd.*, Jan. 25, 1936, *44*, 150–154.

[5] Robins, S. A., and Hermanson, L. Cholangiography; a modified technique for the x-ray visualization of the bile ducts during operation. *Surg., Gynec. & Obst.*, April, 1936, *62*, 684–688.

film is then removed and another one replaced in the drawer. The exposed film is quickly developed and the surgeon is able to view it within six minutes.

It can be readily seen that the technique is a simple one and can be carried out in any operating room provided the roentgenologist is equipped with a shock proof apparatus. The operation is performed according to the indications revealed by the roentgen ray. If the film demonstrates that the common duct is clear and unobstructed, incision and exploration of the duct can be dispensed with. If, on the contrary, the film shows evidence of obstruction suggesting stone, stricture or neoplasm, the duct is opened and explored and the lesion is dealt with according to the surgical indications. After this surgical procedure is completed a catheter or T-tube is inserted in the duct and through it 30 cubic centimeters of hippuran is injected and a second exposure is made. The surgeon is thus able to determine whether or not the obstruction is completely removed. These observers have found that hippuran is a harmless substance which is excreted through the kidneys and in their hands has proved satisfactory in every way. They have used the procedure in twenty-five cases and in only one did the first film fail to agree with the exploratory findings. They found that in four instances the pancreatic ducts were visualized and in these four cases it was of interest to note that chronic pancreatitis was present, as evidenced by enlargement or hardening of the gland. When the pancreatic ducts are visualized it is of considerable diagnostic importance.

In none of the patients was there experienced any untoward reaction as a result of injecting hippuran into the bile ducts. This method of exploration of the common duct furnishes information which is not available by any other diagnostic method. Robins and Hermanson call attention to the fact that small stones, so-called sand bile, will not be shown on the films and that in certain cases where the evidence is not clear cut the clinical evaluation of the case in question will have to be determined by the surgeon, and that the only contraindication to the procedure which merits consideration is the presence of acute infection in the biliary tract.

This method of roentgen visualization of the bile ducts according to the technique of Robins and Hermanson in no way interferes with the conduct of the operation. On the contrary, it provides the surgeon with visual evidence for determining whether or not the common duct should be opened and if opened whether or not the common duct obstruction has been removed. This non-surgical method of exploration of the common duct offers a tremendous aid in biliary tract surgery and should be employed routinely.

AMERICAN RADIUM SOCIETY

THE Twenty-first Annual Meeting of the American Radium Society was held at the Hotel Kansas Citian, Kansas City, Missouri, on Monday and Tuesday, May 11 and 12, 1936, under the presidency of Dr. George W. Grier. The Scientific Program Committee and the other committees having to do with the organization of the meeting laid the plans for what was perhaps one of the most successful meetings that the American Radium Society has ever held. The program was a varied one, dealing with all phases of the physics of radium as well as its therapeutic application. The Arrangements Committee, headed by Dr. E. H. Skinner, provided a meeting hall and other facilities which were adequate to care for a large and interested audience. Not only was the program itself of the highest order but the social amenities incident to the meeting were most pleasant and enjoyable. One of the highlights of the meeting was the banquet held on Monday evening at the University Club at which time the annual Janeway Lecture was given by Dr. Curtis F. Bur-

nam of Baltimore, Maryland, on his "Early Experiences with Radium." Dr. Burnam's personal experience with radium and its therapeutic application peculiarly fitted him as the lecturer. He interspersed his formal paper with many anecdotes which added considerably to the pleasure of the lecture. The papers read in the scientific sessions of the meeting will be published from time to time in the Journal.

The following officers were elected: *President:* Dr. Zoe A. Johnston, Pittsburgh, Pa.; *President-elect:* Dr. E. H. Skinner, Kansas City, Mo.; *1st Vice-President:* Dr. Charles L. Martin, Dallas, Texas; *2d Vice-President:* Dr. O. N. Meland, Los Angeles, Calif.; *Secretary:* Dr. William P. Healy, New York City; *Treasurer:* Dr. Lawrence A. Pomeroy, Cleveland, Ohio.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. F. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting, 1937: To be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting, 1937: To be announced.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting: Cincinnati, Ohio, Nov 30–Dec. 4, 1936.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT STATE MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL SOCIETY
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas. Annual meeting, Baltimore, Md., Nov. 17–20, 1936.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. North W. Shetter, 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. K. D. A. Allen, 452 Metropolitan Building, Denver, Colorado. Meets on any month having a fifth Monday.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Gerard Raap, Miami, Florida. Meetings held twice a year, May and November.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Cesare Gianturco, 602 W. University Ave., Urbana, Ill. Regular meetings held quarterly.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. J. N. Collins, Indianapolis, Ind. Meeting held the second Sunday in May annually.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. M. Dannenberg, 1464 Eastern Parkway, Brooklyn, N. Y. Meets on third Thursday of each month from October to May, at 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing, Mich. Three meetings a year, Fall, Winter, and Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

NEBRASKA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday evening of each month.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. E. C. Vogt, 300 Longwood Ave., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

PACIFIC ROENTGEN CLUB
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, Williamsport, Pa. Next annual meeting June 5 and 6, 1936, Lycoming Hotel, Williamsport, Pa.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Camp C. Thomas, 476 Lake Ave. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

ST. LOUIS ROENTGEN RAY SOCIETY
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. J. H. Smith, Lubbock, Texas
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Roentgen Club
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Española de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. G. Gatoschi, Str. Isvor 14–16, Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

REPORT OF THE ADVISORY COMMITTEE ON X-RAY AND RADIUM PROTECTION OF THE AMERICAN RADIUM SOCIETY

Your Committee on Protection wishes to make its report in the form of suggestions and thereby elicit from the members of this Society discussion as to the merits of the outline of our suggested plan.

The insurance premiums for radiotherapists have been in excess of those paid by men engaged in other branches of medicine. The premiums are based on cost of litigation primarily and, to a lesser extent, on the judgments against doctors engaged in radiotherapy.

Although resolutions passed by this Society may influence a judge or jury to pass judgment in favor of a medical defendant, we believe radiotherapists should formulate and sanction a plan which will make the practice of our branch of medicine a little less hazardous. We must not delay until the legal profession directly influences radiation dosage by establishing a precedent, or indirectly influences it by successive lawsuits.

Your Committee proposes the plan to be suggested, but it requires the cooperation of all members of the Society to make these suggestions into a workable plan.

We suggest that each member of this Society make a report to the Committee on Protection to succeed the present Committee, on any cases of litigation which have been instituted against him over a period of years, the result of such litigation and, also, any important developments in the trial, if it reached such a stage. A few suggestions on how the case might have been better handled, either medically or legally, would help in the formulation of a plan.

In the very near future, your Committee might designate a maximum radiation dosage consistent with the type of disease for which roentgen radiation is used, namely, carcinoma. This dosage could be determined by survey of many clinics in this country and should be the highest dosage consistent with safety, at the same time being adequate to influence the disease. Such dosage should be at this level for two reasons: first, that this Society has sanctioned a dosage which no capable and experienced radiotherapist will exceed and, secondly, to encourage and help those men who are fearful of giving adequate dosage, or are hampered by their associates who will not permit their patients to receive proper dosage. For these reasons, we do not believe any minimum dosage should be designated.

For a working basis, we suggest the following plan for radiation dosage at 200 kv., 0.5 mm. and 1 mm. copper filter, skin portal 10×10 cm., the change of dosage for various other portals to be determined by percentage plus or minus:

1. Total estimated skin tolerance dose of dry exposed surface as head and neck,
   (*a*) at one sitting
   (*b*) over period of ten days
   (*c*) over period of fifteen days
   (*d*) over period of twenty days
   (*e*) over period of thirty days
2. Same for breast.
3. Same for pelvis.
4. Same for moist areas and unexposed, as axillae and groins.
5. Same for extremities.

Included in these dosage figures should be mentioned the time interval, that is, whether radiation is given daily, every other day, or biweekly.

There is no need, at this time, to include supervoltage dosage—these modalities are too few in number and as yet inadequately studied.

The Society has made recommendation for treatment of carcinoma of cervix uteri. This could be incorporated in our plan.

Your Committee asks that these suggestions be thoroughly discussed, for more clarity. Thereafter, each member should tersely write to the Society's Committee his recommendations. From the consensus of these recommendations, the Committee could outline a plan. Such a plan should receive unanimous approval of this Society; otherwise its value will be depreciated.

JAMES J. DUFFY, *Chairman*
WILLIAM H. CAMERON
JAMES L. WEATHERWAX

REPORT OF THE RESEARCH AND STANDARDIZATION COMMITTEE OF THE AMERICAN RADIUM SOCIETY

A great deal of work has been done on questions of optimum methods of application and relative advantages and disadvantages of external, intracavity and interstitial radium therapy in malignant disease.

Indications have been studied for combining roentgen therapy and surgery with, or substituting these for, radium therapy.

Attempts have been made to express radium doses in roentgen units and to apply this to tissue dosage.

These recent advances are now undergoing the test of practical application in various clinics and require careful study before being set up as standards. Therefore, the Research and Standardization Committee respectfully suggests that another year's study is desirable before a more comprehensive attempt is made to evaluate this new information.

Maurice Lenz, *Chairman*
K. Wilhelm Stenstrom
L. R. Sante

REPORT OF THE COMMITTEE ON EDUCATION AND PUBLICITY OF THE AMERICAN RADIUM SOCIETY

The Committee on Education and Publicity had considered the resolutions of the Radiological Society of North America (as published in *Radiology*, 1936, *26*, 246–248) and recommended the support of the American Radium Society of the resolutions as they affect the members of the American Radium Society, and further recommended that the Secretary be requested to notify or report to the proper authority.

Dr. Bowing moved that this report be adopted. The motion was seconded and unanimously carried.

ILLINOIS RADIOLOGICAL SOCIETY

The Illinois Radiological Society met at 10:30 A.M. on Sunday, April 26, 1936, at Champaign, Illinois. After hearing the conclusions of the Committee in charge of the study of the constitution of the Illinois Society of Radiographic Technicians, it was moved and approved that the Illinois Radiological Society endorse the constitution of the Illinois Society of Radiographic Technicians. A film clinic followed and interesting cases were presented by Drs. Morgan, Kariher, Gianturco and Jewell. Dr. James H. Finch presented an apparatus for the reduction of fractures.

After dinner, Dr. C. H. Warfield gave a most complete discussion of the roentgenological aspects of bone tumors. Dr. C. Gianturco presented two instruments for the roentgenographic visualization of the optic canals and the temporal bone in Stenvers' position.

MINNESOTA RADIOLOGICAL SOCIETY

The annual meeting of the Minnesota Radiological Society was held in connection with the meeting of the Minnesota State Medical Association at Rochester, Minn., May 4, 1936.

The Russell D. Carman Memorial Lecture was delivered by Dr. Willis F. Manges of Philadelphia on the subject, "Foreign Bodies and the Use of X-Ray Examination in their Localization and Removal."

At the annual dinner Dr. Manges addressed the members of the Society on "The Future of Radiology."

Election of officers for the coming year resulted as follows: President, Dr. J. Richards Aurelius, St. Paul; Vice-President, Dr. Walter H. Ude, Minneapolis; Secretary-Treasurer, Dr. Leo G. Rigler, Minneapolis.

RADIOLOGICAL SECTION CONNECTICUT STATE MEDICAL SOCIETY

The Connecticut State Medical Society held its One Hundred and Forty-Fourth Annual Meeting at Hartford, Connecticut, May 20–21, 1936. The following papers were given in the program of the Section on Radiology, on May 20:

Results of Comparative Doses on Human Tumors Using Fever and Roentgen Radiation. By Stafford L. Warren, M.D., Rochester, N.Y. Discussion by William S. Stone, M.D., Westport, Conn., and George T. Park, M.D., New York.

Roentgenologic Study of the Appendix. By Hugh Wilson, M.D., New Haven, Conn. Discussion by Ralph T. Ogden, M.D., Hartford, Conn.

At the business meeting which followed the program, the following officers were elected for the coming year: Chairman, R. H. Lockhart, M.D., Bridgeport, Conn.; Secretary-Treasurer, Max Climan, M.D., Hartford, Conn.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

A TEXTBOOK OF ROENTGENOLOGY: THE ROENTGEN RAY IN DIAGNOSIS AND TREATMENT. By Bede J. Michael Harrison, M.B., Ch.M., D.M.R.E., (Cantab) F.A.C.R., Director of Department of Roentgenology, Vancouver General Hospital, Roentgenologist to Vancouver Public Health Institute for Diseases of the Chest. Cloth. Price, $10.00. Pp. 826, with 238 illustrations. Baltimore: William Wood & Co., 1936.

The salient feature of this volume is best described in the words of Dr. A. Howard Pirie who wrote a preface for it: "The contents of this book bring the roentgenologist more into the class of consultant than any other book written up to the present. The author has taken pathology and shows what roentgenology can do in the way of treatment of the pathology or showing up the pathology without resorting to surgery. Other books have emphasized the X-ray film and have worked backwards to the pathology. To many roentgenologists this book supplies the knowledge of pathology which is essential to them. It is a book which should appeal to the clinician as much as to the roentgenologist."

To this might be added several points mentioned by the author in his preface. He states that the book is intended primarily to enable the practitioner to understand the basis on which roentgenology rests so that he may be better able to appreciate the help which the specialty can be to him in his work. It will serve to teach him the scope and limitations of roentgenology. It will enable him to avoid unnecessary expense to which the patient is put when requests are made for roentgenological examinations which are of relatively little value, and, in addition, will help him to decide on those roentgenological examinations which are well worth while to him and his patient. He hopes that the so-called routine roentgen examination will be eliminated.

The author is not aware of any other book in the English language which bridges the gap between morbid anatomy and roentgenology. Throughout the volume he stresses the histological changes present in different disease conditions with the object of inculcating the basic idea that roentgen therapy depends upon a thorough understanding of morbid histology, in the same way that roentgen diagnosis depends upon a knowledge of the gross pathological changes which are in themselves expressions of the histological processes.

The problems of roentgenological technique are outlined so far as the factor of distortion of shadows is concerned, in the hope that an appreciation of these facts by the clinician will lead to a closer cooperation with the roentgenologist and thereby secure the utmost freedom for the latter to vary his technique to suit the investigation. The first four chapters of the book deal with Physics, Radio-Physiology and Biology, Technical Considerations and the Nature of Roentgen Evidence. Thereafter the arrangement is very much like the usual textbook of pathology, covering general and special pathology. Pathological processes are described in detail. The author has made no attempt, he says, to meet the needs of the roentgenologist who has at his disposal a library of special works on the subject with which each chapter of the book deals. This book therefore differs from the usual textbook of roentgenology in that illustrations of roentgenograms of the various pathological processes are comparatively few. Nevertheless, the author feels that the point of view that has been stressed throughout the work may be of value to those who intend practicing as roentgenologists if it acts as a stimulus to them to pursue the study of pathology as closely as they do that of roentgenology.

If this book is to serve as a stimulus to further investigation by students of roentgenology, it would seem that the complete omission of all references to the literature on the various subjects discussed is regrettable. On reading that parathyroid irradiation should be tried before parathyroidectomy in cases of adenoma of the parathyroid, or that gastric hyperacidity can often be cured entirely by a course of roentgen therapy extending over one to three months, or that roentgen therapy in gastric ulcer usually causes the subjective

symptoms and pain to disappear, and that permanent healing of a gastric ulcer, treated by irradiation, may occur, a reader may naturally desire to consult the original sources for authority for such statements. It appears that too many moot questions are dismissed with definite statements, leaving the reader with no inkling of where he can obtain further information.

When the scope of the work which has been confined to a book of 826 pages is taken into consideration, a lack of full discussion and explanation of debatable subjects can easily be understood. But there may be a question whether the inclusion of congenital erythroblastic anemia under the heading of von Jaksch's anemia without greater explanation than that given in the text is desirable. It has not yet been proved that the cases described by von Jaksch were similar to those described by Cooley as erythroblastic anemia of congenital origin. As Baty, Blackfan and Diamond observe, the name of von Jaksch has been associated with many disturbances in infancy and childhood characterized by anemia, splenomegaly and the presence of immature cells in the peripheral blood so that the diagnosis has served for many etiologically unrelated conditions.

Such instances are few in number, however, and when the work as a whole is considered, it has so much of merit that it should fulfill the expectations of the author and prove its worth for both the roentgenologist and the clinician.

Ralph S. Bromer

Atlas der normalen Ossifikation der menschlichen Hand. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Erganzungsband 47.) Von Prof. Dr. F. Siegert, Ehemals Direktor der Universitäts-Kinderklinik Köln. Paper, price M. 16.—; bound, M. 18.— Pp. 43, with 8 illustrations in the text and 36 plates. Leipzig: Georg Thieme, 1935.

This is truly an age of specialization, a fact well illustrated by the devotion of a volume of nearly a hundred pages to so specialized a subject as the ossification of the human hand. Some such works are merely curiosities and monuments to the patience of their authors. We feel that this work, however, has great practical value. Roentgenologists are constantly being beseeched by endocrinologists and pediatricians for aid in problems of arrested or accelerated development and the help they receive is too often disappointing because of the lack of accurate knowledge of the normal and its variations. The bones of the wrist and hand are conceded to give more useful information than others and it is therefore practical to concentrate attention on them.

Dr. Siegert gives us the most carefully worked out and complete set of tables and illustrations we have been privileged to examine. For example, there are over fifty plates of the male hand illustrating the various periods of growth, and an equal number of the female hand. There are also over fifty illustrations of normal variations of development of the male and female hand. By means of condensed tables each case is fully commented on as to the particular significance of the findings.

Interspersed with the text are tables comparing the growth and development of the bones as given by Adam, Kornfeld, Pirquet and others. The reader can readily judge the value of such a work for daily reference.

E. Walter Hall

La broncografia en el estudio de la afecciones del torax. By Raul P. Blanco and Federico G. Capurro. Pp. 397, with 168 illustrations. Montevideo: Imp. El Siglo Ilustrado, 1935.

This is a thorough and successful attempt to present the subject of bronchography in all its phases. The book is divided into two parts. The first part, subdivided into three chapters, deals with the preparation of the patient and the technique of bronchography (including the anesthetics employed), the accidents that may occur and the contraindications, and the normal anatomy and motor physiology of the respiratory apparatus as they apply to bronchography. The second part is subdivided into ten chapters, dealing with the pathologic types of bronchographic images, intrathoracic neoplasms, congenital malformations, bronchial dilatation, pulmonary abscesses, echinococcus infestation of the lungs, the diagnosis of basal lesions, pulmonary tuberculosis and syphilis, and disturbances of motor physiology as these are observed in the respiratory tract. The logical arrangement of the material deserves commendation. The book is printed in readable type, on good paper, but the quality of the illustrations might perhaps be improved. In discussing the various phases of the subject the

authors first present the work of others, the various modifications of technique with their respective advantages and disadvantages, and then give their own ideas which, in general, are quite sound. Case reports are often given to illustrate certain points. At the end of the book is an essentially complete bibliography. To those who read Spanish this work is heartily recommended because it is an excellent review of the subject up to date.

A. U. Desjardins

Clinical Miscellany: By members of the staff of the Mary Imogene Bassett Hospital, Cooperstown, New York. Vol. II. Cloth. Price, $3.00. Pp. 218, with 50 illustrations. Springfield, Illinois: Charles C Thomas, 1935.

This second volume of Clinical Miscellany consists of twenty contributions by the staff of the Mary Imogene Bassett Hospital of Cooperstown, New York. The articles are, for the most part, a presentation of case histories of unusual interest which indicate a careful study and analysis of the conditions by a group of critical workers. The book reflects a most commendable spirit on the part of these physicians and should serve as a stimulus and ideal pattern for other smaller hospitals which do not have a close affiliation with teaching institutions or a large medical center. The contributors of this volume are making a sincere, and I believe successful, attempt to correlate the procedures of the laboratory with the "insight, humanitarism and art of traditional medicine" which is surely a meritorious objective. The subject matter of the articles is diverse but practical, varying from such topics as "Some remarks on the treatment of large decubitus ulcers" to "A six-year experience with acute anterior poliomyelitis in a rural community."

C. C. Sturgis

Free Medical Care (Debater's Help Book, Volume II). Compiled and edited by E. C. Buehler, Director of Forensics, University of Kansas. Cloth. Price, $2.00. Pp. 360. New York City: Noble and Noble, Inc., 1935.

The subject of socialized medicine is being used as a topic for debate in the high schools of the United States at the present time and this book is an effort to place before the student the problem as its exists both pro and con.

The first part of the book is devoted to a definition of the terms used in the discussion of the subject with an outline of arguments for and against socialized medicine. This is followed by a bibliography of the literature that has appeared in the many publications.

Although the literature has appeared in such great abundance relatively few articles contain material which deal with identical features of the affirmative proposal. Thus the greater portion of the book is devoted to the reprint of outstanding articles that have appeared both for and against the system of socialized medicine.

That the subject matter is timely is evident. The book contains a valuable source of information for those who are interested in the problem.

Harold B. Fenech

The Liverpool Medico-Chirurgical Journal, 1935, *43*, Part 1. Hugh Owen Thomas Centenary Number.

This number contains two very interesting papers, one being T. P. McMurray's Life of Hugh Owen Thomas, the other, The Lady Jones Lecture on Malignant Tumors of Bone. The life of Thomas should be especially interesting to students of medical history but even the average physician who has little time or inclination for anything but his practice and scientific reading cannot but be entertained by such an account of the strange and colorful life of this great physician. His ancestry of a long line of unlicensed healers and bone setters, his association with his own father in an alliance criticized by his own scientific peers, his triumph over physical handicap, circumstance and jealous opposition, becoming one of the great surgeons not only of his day but of all time, reads like an imaginative romance. The sketch which McMurray gives cannot but leave the reader with a thirst for more details of this man's career and a desire to read his published works. Hugh Owen Thomas, known to every medical student, hospital attaché, and many patients by his most famous "Thomas splint" contributed much of value to medical science in addition to his orthopedic appliances. However, it is through his orthopedic work that he most influenced the trend of surgical procedure and it is indeed fitting that his memory should be kept alive by the establishment of a memo-

rial orthopedic library. And inasmuch as the life and work of Thomas so greatly influenced and was carried on by his nephew, that greatest of orthopedists, Sir Robert Jones, it is appropriate that the two should be honored by the same project.

The author of the sketch of Thomas' life appeals to all contributors to orthopedic literature to send copies of their books and papers to the Hugh Owen Thomas and Robert Jones Memorial Library, 114 Mount Pleasant, Liverpool, England, that the material may be truly representative and complete. We heartily commend this worthy undertaking and trust that all will cooperate in furthering it.

E. Walter Hall

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

A SAFETY DEVICE FOR ROENTGEN APPARATUS*

By FRANCIS W. BISHOP
ROCHESTER, NEW YORK

THE DEVICE about to be described represents an attempt to safeguard the operator or patient in case of accidental contact with the high tension system of roentgen machines or similar apparatus. It should also prevent the cracking of a roentgen tube which so often occurs when there is an arc-over from the end of the tube to some part of the tube stand or holder.

The high tension circuit of roentgen apparatus may be compared with a balanced three wire distribution system where the neutral wire is carrying no current (Fig. 1, *a*). The center tap of the high tension winding on most roentgen transformers is grounded. Under ordinary circumstances and regardless of the load on the secondary, no current flows from this center tap to the ground. However, if contact should be made with either side of the high tension system or if a spark-over should occur from either side of the system to ground, a current does flow which may be used to automatically shut off the machine. All that is necessary, therefore, is to break the circuit between the center tap of the high tension transformer and the ground, and insert a sensitive relay, the contacts of which may open or close any appropriate circuit in the control board or operate a circuit breaker, etc., when current passes through the winding of this relay (Figs. 1 and 2). Since the

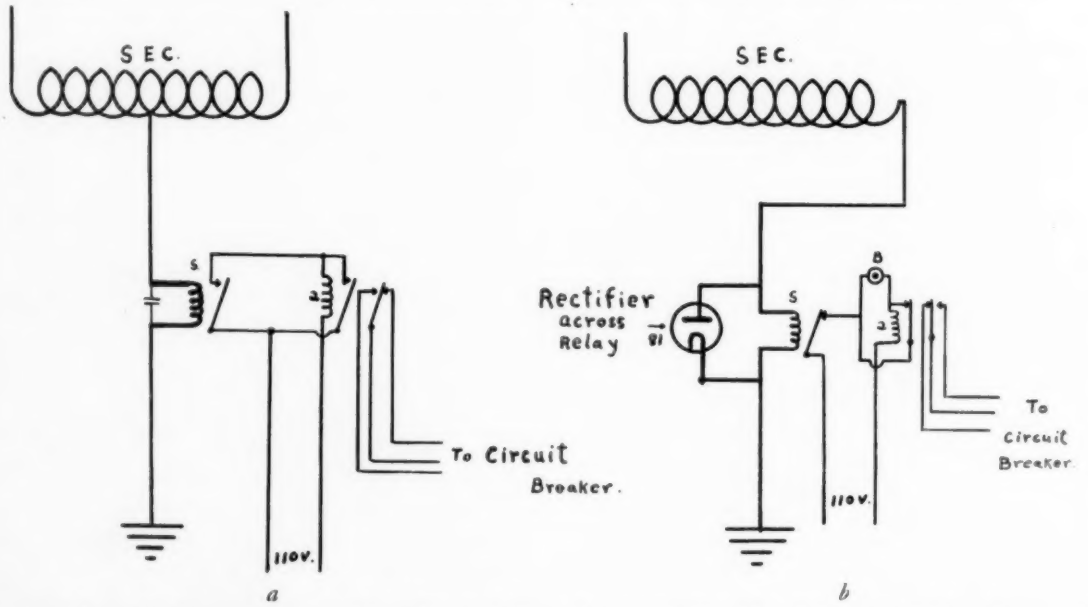

FIG. 1. Schematic diagram of protective relay circuits. *a*, shows sensitive relay *S* in center tap lead to ground. When relay *S* is energized, relay *2* holds circuit breaking device open until reset by opening and closing main switch; *b*, shows sensitive relay *S* in grounded end of secondary of self-rectified unit. The load current is carried by a type 81 rectifier tube, the relay *S* being effectively short circuited. Inverse currents pass through relay *S* causing relay *2* to drop out and remain so until reset by button *B*. Dry disk rectifiers have too small a ratio of rectification at the usual roentgen currents to be very effective.

* From the Department of Medicine, Division of Radiology, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.

relay circuit is not affected by any symmetrical load across the roentgen transformer, such as a roentgen tube, it does not influence in any way the ordinary operation of the machine. Therefore, one may use a very sensitive relay which may operate on a few microamperes. Tests show that the machine so protected may shut off within one or two alternations. The time depends entirely upon the inertia of the relay and contactor or circuit breaker.

Because of the short duration of current flow, the sensitive relay is not harmed by the overload. The relays here employed, although of the D.C. type, operate perfectly well on self-rectified units. It may be desirable to connect a small condenser (1 microfarad) across the relay winding and also a small safety gap of a few thousandths of an inch. In the case of a machine operating with one end of the secondary grounded (with no center tap) such as some types of dental and diffraction apparatus, it is necessary to use a relay possessing a discriminating action so far as current direction is concerned (Figs. 1, *b*, and 3). When the machine is self rectified and operating with one end of the secondary grounded, the device should not be affected by the load current but can be controlled by inverse current, which flows when the "hot" side of the high tension system is touched or grounded, and also if the tube becomes gassy.

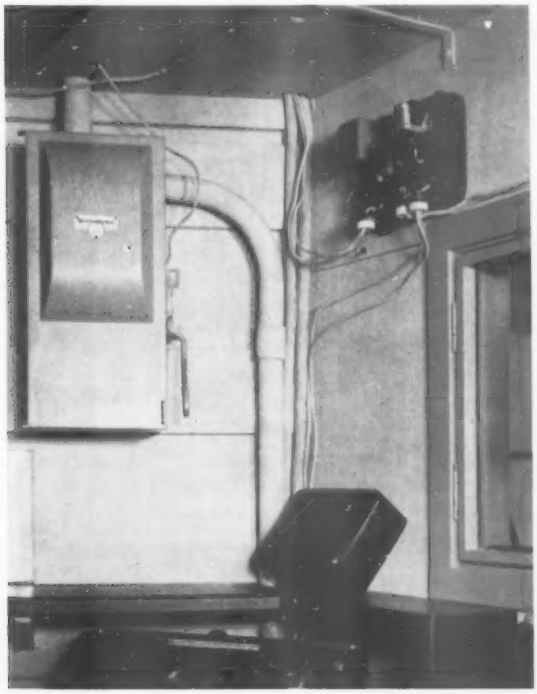

Fig. 2. Protective relay mounted in roentgenographic cubicle. A second relay holds the circuit open after spark-over until reset by opening and closing main switch.

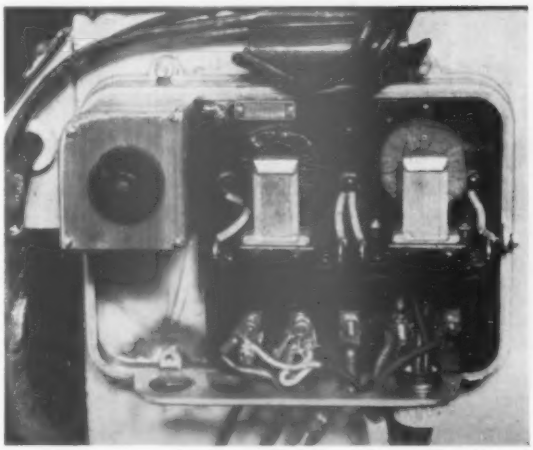

Fig. 3. Protective relay mounted on diffraction apparatus. A second relay holds the circuit open after spark-over until reset by push button.

The device may be used on machines of any type as a protection in case of puncture of high tension cables, condensers, spark to inside of transformer case due to low oil, leaky insulation, etc., before there is time for serious damage and burning. Instead of the usual hot red flame from a spark-over, there is, when the device is employed properly, only a rather weak blue spark probably not sufficient to crack a tube due to the heat, and the sensitivity and rapid action of the device greatly reduces the hazard to life.

There is some difficulty in using the protective relay in connection with mechanically rectified machines due to the large amounts of high frequency currents flowing in the center tap lead to ground. This difficulty can be surmounted by the use of suitable by-pass circuits.

SUMMARY

A safety device has been described which is intended to shut off the roentgen apparatus if accidental grounding occurs in the high tension circuits, thereby protecting apparatus and reducing hazards.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Abdomen

MORRISON, T. H., and FELDMAN, M.: The redundant duodenum 837

MUCCHI, L.: The importance of roentgen examination when gastroduodenal perforation is suspected 837

ROSSONI, R.: Cases of extrabulbar ulcer of the duodenum 838

RUNCO, A.: Common mesentery 838

SHAY, H., and GERSHON-COHEN, J.: The diagnostic value of the double contrast enema; with special reference to the diagnosis of early neoplastic lesions of the colon 838

STEWART, W. H., and ILLICK, H. E.: High- and low-power roentgenographic differentiation between diverticulitis and cancer of the sigmoid 839

STEIN, I. F.: Oxygen pneumoperitoneum in the diagnosis and treatment of tuberculosis of the genitalia, intestine and peritoneum 839

Skeletal System

TOWNE, E. B.: Injuries of the spinal cord and its roots following dislocation of the cervical spine 839

KREBS, W.: The roentgen appearance of the pelvis in Bechterew's disease 839

MANKOWSKY, B. N., HEINISMANN, J. I., and CZERNY, L. I.: Osteopathia dysplastica familiaris (the genesis of Marie-Bamberger's syndrome) 840

SCHAAP, C.: Intrapelvic protrusion of the acetabulum 840

FERGUSON, A. B., and HOWARTH, M. B.: Coxa plana and related conditions at the hip 840

OVERTON, L. M., and GHORMLEY, R. K.: Congenital fusion of the spine 842

WAGNER, L. C.: Congenital defects of the lumbo-sacral joints with associated nerve symptoms 842

JOHNSON, R. W.: Posterior luxations of the lumbosacral joint 842

SMITH, ALAN DEF.: Posterior displacement of the fifth lumbar vertebra 843

ABRAMSON, D., ROBERTS, S. M., and WILSON, P. D.: Relaxation of the pelvic joints in pregnancy 844

SAGEL, J.: Acute osteomyelitis (osteitis) of the patella 844

JANSSON, G.: Changes in the skeleton in Schüller-Christian's disease 845

GESCHICKTER, C. F., and LEWIS, D.: Tumors of tendon sheaths, joints, and bursae ... 845

CAMPBELL, W. C.: Endothelial myeloma 845

CONNOR, C. L.: A further consideration of Ewing's sarcoma 847

BERGSTRAND, H.: Osteitis fibrosa of Recklinghausen, heterotopic parathyroid adenoma, metastases of a benign adenomatous struma and adenoma of the left adrenal in the same patient 847

MILCH, H.: Giant cell tumor of the spine ... 848

WENGER, F.: How do defects in bone heal? ... 848

KEWESCH, E. L.: Hereditary fusion of the bones of the hand and foot 849

HUMMEL, R.: Union of spontaneous fractures caused by metastatic carcinoma in bone 849

Blood and Lymph System

HUTTER, K.: Roentgen demonstration of the pelvic vessels in urological cases 849

ROENTGEN AND RADIUM THERAPY

QUINEY, J. J.: Hyperthyroidism treated by irradiation 849

FARRELL, J. T. JR.: Roentgen therapy versus surgery in the treatment of hyperthyroidism 849

LUND, C. C.: Comparison of apparent end results in cases of carcinoma of the mouth in relation to length of follow-up 849

BYCHOWSKY, M., FRANKEL, J., and EISENBERG, M.: Roentgen rays as a means for combatting diphtheria carriers 850

MARTIN, H. E.: The fractional or divided dose method of external irradiation in the treatment of cancer of the pharynx, tonsil, larynx and paranasal sinuses 850

COVENTRY, W. A., and MOE, R. J.: Ten years of surgery for cancer of the breast 851

HICKEN, N. F.: The management of thyroid malignancies 851

CROSSEN, H. S.: Treatment of cancer of the cervix uteri 851

STORCK, A. H.: Cancer: A brief résumé of methods of palliative surgical treatment 852

PARKES, W. R.: Cancer treatment results as shown in twelve year survey at Evanston Hospital 852

KEYES, E. L.: Five year results of suprapubic radium implantation into bladder tumors 852

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ABDOMEN

Morrison, Theodore H., and Feldman, Maurice. The redundant duodenum: clinical significance. *Ann. Int. Med.*, March, 1934, *7*, 1126–1134.

The authors discuss the redundant duodenum, the diagnosis of which is based almost entirely upon the roentgen study. In these cases an elongation or lengthening of the superior segment of the duodenum is observed, resulting in the formation of an anomalous loop, thus permitting the retardation of the opaque meal. The duodenal cap is not affected, although in some instances the extra loop appears to be a part of the cap, leading to the impression that an enlarged cap or diverticulum is present. This is due to a coalescing of the two shadows and may be differentiated by manipulation. The diminished motility with consequent stasis which the condition promotes produces syndromes otherwise difficult to interpret.

The authors discovered 12 cases in a series of about 500 routine gastrointestinal examinations. The symptoms are not characteristic and may be due solely to an associated lesion. The usual complaints are anorexia, nausea, vomiting, epigastric discomfort and headache. Duodenal stasis, present in all of the authors' series, may account for many of the symptoms. Peptic ulcer was frequently found and, when absent in this series, duodenitis was noted. These changes are assumed to be the direct effect of the redundancy producing a stasis and consequent local injury to the mucosa.

The condition is best recognized on roentgenoscopic examination, but to make certain that the condition is permanent, the examination should be repeated. Early recognition and effective treatment may prevent the occurrence of secondary complications.—*W. R. Brooksher.*

Mucchi, Ludovico. L'importanza dell'esame radiologico nel sospetto di perforazione gastro-duodenale. (The importance of roentgen examination when gastroduodenal perforation is suspected.) *Radiol. med.*, Feb., 1935, *22*, 93–120.

Based on 29 cases seen in the past two years the author discusses the value of roentgen examination in suspected perforation of the stomach or duodenum. The examination is entirely free of danger and may be extremely valuable as it may be the only means of making a diagnosis and it may be possible to make a diagnosis in this way earlier than by clinical examination. In 3 of his cases the clinical diagnosis was appendicitis, while roentgen examination showed the true condition which was confirmed on operation. In 10 cases the clinical and roentgen diagnoses agreed and were confirmed on operation. In 4 cases the perforation diagnosed more or less clearly by clinical examination was not confirmed on roentgen examination but was confirmed on operation; in 2 of these cases, however, the roentgen examination had showed signs of peritonitis. In 3 other cases clinical examination indicated perforation but roentgen examination did not confirm it and operation showed the correctness of the roentgen diagnosis. In 9 cases roentgen examination definitely excluded a more or less uncertain clinical diagnosis of perforation.

Roentgen examination may be made in the patient's home by means of a portable apparatus during the first few hours of the acute abdominal syndrome, which is of great practical advantage. Roentgenoscopy and roentgenography should be carried out with the patient lying on his back, first in the dorsoventral and then in the transverse direction.

The most characteristic appearance is that of free air in the abdomen; there is a transparent semilunar or sickle-shaped area with a fluid level below it in the subphrenic space. Or there may be a rounded area of greater transparency in the midst of the liver dullness. Even the little gas bubbles which form between the liver and the diaphragm are visible in the roentgenogram. The diagnosis is based essentially on the visibility of extraintestinal gas but in about half the cases there are also signs of peritonitis and an abdominal effusion. The roentgen diagnosis is incorrect in not more than 5–10 per cent of the cases. Immobility of the diaphragm is an evidence of peritonitis, not of perforation. Reduction or disappearance of liver dullness may be a deceptive sign as it may

be caused by interposition of a part of the distended colon between the liver and the diaphragm. In cases in which the result of roentgen examination is completely negative immediate surgical intervention is not indicated. —*Audrey G. Morgan.*

ROSSONI, RICCARDO. Contributo casistico allo studio dell' ulcera extrabulbare del duodeno. (Cases of extrabulbar ulcer of the duodenum.) *Radiol. med.*, March, 1935, *22*, 225–237.

Five cases of extrabulbar ulcer of the duodenum are described and illustrated with roentgenograms. There are no clinical symptoms by which extrabulbar ulcer can be definitely differentiated from ulcer of the bulb or stomach. In 3 of these cases the ulcer was at the upper flexure of the duodenum, in the other two it was in the juxtapapillary part of the descending portion. The most characteristic finding was an opaque diverticulum; it is difficult, however, to differentiate this from inflammation or true diverticulum. The differentiation may be made, however, by a careful study of the adjacent part of the duodenum. Aside from the finding of an extrabulbar niche the most important roentgen signs of ulcer are a more or less pronounced spastic stricture of the duodenum at the site of the ulcer with disappearance of the normal design of the folds, which if studied with care can be differentiated from the picture in tumor and an incisure of the stenotic tract which has the same value as Cole's symptom in the bulb, dilatation below the constriction and circumscribed pain on pressure over the lesion. A combination of these signs suggests a strong probability of extrabulbar ulcer and should induce the roentgenologist to make the most careful possible examination for a niche which is the only absolute sign. *Audrey G. Morgan.*

RUNCO, ANTONIO. Sul "Mesenterium commune." (Common mesentery.) *Radiol. med.*, Feb., 1935, *22*, 147–163.

The author reviews the embryology of the small intestine, illustrating it with diagrammatic drawings. He then describes 3 cases of common mesentery which are illustrated with roentgenograms and diagrammatic drawings. He concludes that these cases were due to an arrest of development of the intestine during the tenth week before the rotation of the middle loop around the axis of the superior mesenteric artery has begun.

These cases of common mesentery may not cause any symptoms for a long time but in the majority of cases they cause painful dyspeptic symptoms due to a neurosis of the vegetative nervous system with hypertonia of the vagus. There are also frequently organic changes in these cases, such as appendicitis, ulcer and tumor of the stomach, renal calculus, etc., suggesting that the common mesentery is a point of least resistance for the development of organic lesions. Complications directly due to the anomaly are also frequent, such as volvulus, torsion and invagination.

Non eof the clinical symptoms are pathognomonic; the most that they can do is to suggest the possibility of the condition for which a thorough roentgen examination must then be made. The whole gastrointestinal tract should be examined by contrast meal and enema, with the patient standing and lying down and also in the Trendelenburg position, so as to show possible organic lesions, stenoses, adhesions, etc. Roentgen examination of the bile and urinary tracts should also be made.—*Audrey G. Morgan.*

SHAY, HARRY, and GERSHON-COHEN, J. The diagnostic value of the double contrast enema; with special reference to the diagnosis of early neoplastic lesions of the colon. *Surg., Gynec. & Obst.*, Jan., 1934, *58*, 52–57.

The authors discuss their technique. The advantages of the double contrast method of following evacuation of an opaque enema with injection of air are enumerated. This method gives help in the differentiation between an irritable colon with spasm in which the remaining opaque material is uniformly distributed over the mucosa in contrast to a true colitis, in which case there is an irregular distribution of the barium with a mosaic or lace-like appearance. A more complete picture of the number of diverticula and their distribution is obtained by the double contrast method. The presence of tuberculosis as characterized by hyperperistalsis, antiperistalsis, pain, tenderness and changes in the outlines and contours of the terminal ileum and colon can be demonstrated by roentgenoscopic and roentgenographic examination with the opaqie enema. The double contrast method has found its greatest usefulness in making visible intraluminal polypi and

minimum neoplastic lesions of the mucosa, so small as to be generally overlooked.—*J. H. Vastine.*

Stewart, Wm. H., and Illick, H. Earl. High- and low-power roentgenographic differentiation between diverticulitis and cancer of the sigmoid. *N. York State J. M.*, Dec. 15, 1934, *34*, 1075–1078.

Clinical information is most valuable to the roentgenologist in any study of the colon. The roentgenographic technique employed by the authors is detailed, and the roentgen signs are fully discussed. The roentgen findings are likely to be more definite in cancer. The filling defect is constant, the involved area is fixed in position, and a palpable tumor may be present. Clinical and roentgenographic signs of the two lesions are presented in tabular form.—*W. R. Brooksher.*

Stein, Irving F. Oxygen pneumoperitoneum in the diagnosis and treatment of tuberculosis of the genitalia, intestine and peritoneum. *Surg., Gynec. & Obst.*, March, 1934, *58*, 567–577.

A diagnosis of tuberculous salpingitis, the commonest cause of tuberculous peritonitis, is often difficult to establish. Tuberculosis constitutes 5 to 10 per cent of inflammatory lesions of the fallopian tubes. Oxygen pneumoperitoneum is a safe and simple method of diagnosis and treatment of tuberculous salpingitis which has almost escaped general notice. The insufflation is used both diagnostically and therapeutically since oxygen pneumoperitoneum is a valuable therapeutic measure not only in tuberculous salpingitis but also in intestinal tuberculosis and various forms of tuberculous peritonitis if used in the early stage, having supplanted laparotomy for these conditions in the author's experience, and he cites 64 such cases from the literature satisfactorily treated, and adds 6 of his own.

Oxyperitoneum is applicable to children and adults. It is contraindicated in the presence of grave pulmonary tuberculosis, advanced, ulcerative intestinal tuberculosis, and in the terminal moribund cases. There is some question whether introduction of the needle can be safely made in the plastic form of tuberculosis. During the first three months of pregnancy when the uterus is not likely to be traumatized by puncture there is no harm in small, repeated oxygen insufflations.

Technique. The bowels are emptied an hour before by a cleansing enema. Morphine (grams $\frac{1}{4}$) and scapolamine (grams 1/150) for the average patient are given a half hour before the procedure. The bladder should be empty. A 3-inch needle with a stylette is introduced at a point 1 inch to the left of and slightly below the umbilicus. About a liter of oxygen produces little discomfort and is sufficient. The patient is kept flat on the roentgen table. Shoulder pain is caused by gas entering the right subdiaphragmatic space. This may be prevented or relieved by keeping the patient flat or elevating the hips. The oxygen has usually disappeared in forty-eight hours.—*J. H. Vastine.*

SKELETAL SYSTEM

Towne, E. B. Injuries of the spinal cord and its roots following dislocation of the cervical spine. *Surg., Gynec. & Obst.*, Dec., 1933, *57*, 783–787.

Dislocations of the cervical vertebrae always damage the structures of the spine, frequently injure the roots of the spinal cord, sometimes causing a complete transection of the cord. There is frequently an associated fracture of the articular processes and crushing of the anterior portions of the vertebral bodies. Dislocations are most common in the lower cervical spine. Laceration of the spinal cord results in permanent interruption of the involved fibers, because, being upper neurons, they cannot regenerate. There is blocking of impulses due to edema and hemorrhage in the tissues of the cord. Prognosis as to permanent disability is difficult therefore, during the first two weeks.

Lateral roentgenograms should be made without disturbing the patient and with a portable machine with the patient on his back. Reduction should be attempted as soon as possible by the closed method, being followed immediately by application of plaster cast. Frequent lateral films are suggested to ascertain maintenance of good position.—*J. H. Vastine.*

Krebs, W. Das Röntgenbild des Beckens bei der Bechterewschen Krankheit. (The roentgen appearance of the pelvis in Bechterew's disease.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1934, *50*, 537–542.

From a roentgenologic study of patients with Bechterew's disease, Krebs concludes that bilateral marked changes in the sacroiliac joints are the earliest and most characteristic signs of

this disease. These are often accompanied by periosteal changes (irregular decreased density and roughening of the pubic bone and ischium) which the author feels are caused by diseased fibrous tissue and periosteum characteristic of Bechterew's disease. By these signs early recognition of the lesion is facilitated.—*E. T. Leddy.*

MANKOWSKY, B. N., HEINISMANN, J. I., and CZERNY, L. I. Osteopathia dysplastica familiaris. (Zur Genese des Syndroms Marie-Bamberger.) (Osteopathia dysplastica familiaris. (The genesis of Marie-Bamberger's syndrome).) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1934, *50*, 542–549.

The authors describe and illustrate a typical case of Marie-Bamberger's disease and cite 2 others to show that this syndrome can occur without disease of the internal organs. The familial occurrence of 2 cases shows the rôle of constitutional and genotypic factors in these cases. A peculiarity of the authors' cases lay in the evidence of a dystrophy (hypertrophy of the bones, general osteoporosis) which seems to point to the fact that in the Marie-Bamberger syndrome an ossifying periostitis does not exist. In some cases with this disease there may be no periosteal reaction or osteoporosis (atrophic type).—*E. T. Leddy.*

SCHAAP, C. Intrapelvic protrusion of the acetabulum. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 811–815.

Schaap reports 2 cases of intrapelvic protrusion of the acetabulum. He states that this deformity has been described but once in the Dutch literature. Pomeranz (1932) recognized two different classes of the condition, the first type being probably of infectious origin; the second type is chronic in character occurring in the course of any disease, resulting in an osteomalacia of the hip joint. Schaap agrees that there cannot be any doubt concerning the occurrence of the acute form, but, in the case of the second, he believes that the connection of this deformity with any disease should be denied and that the cause should be sought in a totally different direction.

In the study of the cases reported in the literature he states that distinct evidence of inflammation is lacking; a great number of cases are bilateral and the majority occur in women; the acetabulum in most cases is deep and the floor is too thin; the curvature of the neck of the femur approaches that of a coxa vara deformity. He concludes that there is a first type originating in consequence of an acute arthritis of the hip joint, and a second resulting from a congenital too deep acetabulum. The article is illustrated with tracings showing the shallow acetabulum and coxa valga deformity in cases of congenital dislocation of the hip with the transition to the subluxation forms, the normal hip and finally to the too deep acetabulum and tendency to coxa vara deformity found in cases of intrapelvic protrusion.—*R. S. Bromer.*

FERGUSON, ALBERT B., and HOWARTH, M. BECKETT. Coxa plana and related conditions at the hip. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 781–803.

Part 1 of this paper, the authors state, is written for the purpose of classifying and correlating coxa plana and related conditions at the hip joint. They include slipping of the upper femoral epiphysis, osteochondritis dissecans, a certain group of cases of chronic degenerative arthritis, and a condition not previously identified as a classical entity, to which they give the name coxa magna. They attribute these conditions to a circulatory disturbance, ischemia, located in or adjacent to the femoral head. The above mentioned conditions are not primary diseases but are the result of the underlying ischemia, the cause and distribution of which may vary. The condition resulting from the ischemia is determined by the age of the patient, the distribution and degree of ischemia, and, to a slight extent, by sex and some minor factors.

They divide the types of ischemia with their sequelae into the following:

Type 1. Inflammation in the hip joint which results in either coxa plana, slipping epiphysis, coxa magna, or degenerative arthritis. They define coxa magna as a case which presents the clinical picture of coxa plana but which has the roentgenographic findings of a growth disturbance, such as elongation of the femoral neck, broadening of the head and neck, and premature ossification of the growth disc of the femoral head and greater trochanter. The capsule of the hip joint is prominent laterally and some decalcification may be present.

Type 2. Inflammation, or rarely, tumor adjacent to the joint, usually in the femoral neck,

of which the sequelae are coxa plana, slipping epiphysis, coxa magna or chronic arthritis.

Type 3. Fracture or epiphyseal separation at the femoral neck, extracapital traumatism of which the sequelae are coxa plana and possibly coxa magna. The authors have never seen a case of slipping epiphysis follow a known fracture of the femoral neck.

Type 4. Trauma to the femoral head which is followed by either coxa plana or osteochondritis dissecans. The latter occurs in late adolescence or adult life.

Type 5. Tension of the soft tissues about the femoral neck. This type of ischemia may cause coxa plana and may be a contributing factor in the ischemia caused by extracapital traumatism, aided by the method of treatment and immobilization, in conditions arising from other types of ischemia.

Subacute arthritis may occur and subside without sequelae in cases where the degree of involvement is slight or the hip is not vulnerable. Broad, shallow, and sometimes irregular femoral heads occur in some forms of chondrodystrophy. These are not to be confused with coxa plana, which is characterized by irregular ossification of the head and by symptoms and signs of inflammation which are not present in chondrodystrophy unless complicated by actual coxa plana or a related condition.

In Part II, the authors discuss and report a study of 75 cases of coxa plana. They describe its incidence and characteristics of onset and divide it into three stages: active, reparative, and residual. The onset and development of these stages usually do not coincide clinically, pathologically or roentgenographically; each stage generally begins and ends later in the bone than in the soft tissues (synovial membrane, etc.). The clinical course, pathology, roentgenographic features, differential diagnosis, the course of the disease in untreated cases, results of various forms of treatment, and choice of methods are very fully discussed.

In an appendix is given a summary of the roentgenographic features of the disease as follows:

1. Incipient Stage: distended capsule; cartilaginous joint space wide, especially inferiorly; slight flattening of the crest of the head; slight radiolucence of the neck at the epiphyseal disc; widening of the epiphyseal disc.

2. Active Stage—Early: dense line at the crest or base of the head; shallowness and broadening of the head.

3. Active Stage—Late: irregularity of the neck; dense areas within the head; greater degree of widening of the joint space, shallowness of the head, and broadening of the head and neck; occasionally some decalcification of the innominate bone and upper half of the femur; ischium varum common (this is a transient feature of the disease, not present until late in the active stage and therefore cannot be considered to be a cause of coxa plana); atrophy of the thigh, demonstrable roentgenographically; protrusion of the head laterally beyond the ilium due to broadening of the head and widening of the cartilaginous joint space inferiorly; body of the pubis on the affected side is smaller than normal which, however, is not necessarily permanent.

4. Transition from the Active to the Reparative Stage: decrease of density in previously dense areas, with appearance of irregular ossification as the density decreases; new areas of density may have appeared while the first areas were becoming irregularly ossified; occasionally irregular ossification in cartilaginous areas at the margins of the epiphyseal line; obliquity of the roof of the acetabulum; lengthening of the acetabulum; occasionally semblance of separation of a fragment of bone at the surface of the head, due to the extensive loss of texture in developing irregular ossification. (This may be designated as the osteochondritis dissecans type of coxa plana.)

5. Reparative Stage: dense areas are almost completely replaced by irregular ossification which is becoming irregular; line of increased density may persist at margin of area of irregular ossification; coarse texture of the trabeculation of the femoral neck; narrowing of the shaft of the femur, not common; occasionally semblance of cavity in the head or in the neck adjacent to the head, due to extensive loss of texture of the head in developing irregular ossification; advanced ossification of the epiphyseal discs of the trochanters or cartilage plate between the ilium and ischium.

6. Reparative Stage—Late: texture of the affected areas tends toward normal; head becomes less flat, the rounded contour being derived from the highest remaining point of the head; the broadened head may have spread down over the neck in the regions where the edge of the head had been irregularly ossified; acetabulum tends to conform to the contour of the head; shortening of the neck, due to deficient growth in length; distention of the

capsule diminishes, if it has not already done so; joint space becomes less wide.

7. Residual Stage: margin of the head where it has grown down over the neck develops a dense line crossing the neck, often quite near the trochanters. (When this line is definite the the process may be regarded as completed, although occasionally there is a little further repair to be accomplished); head has become rounded unless pressure of the upper lip of the acetabulum on a subluxated or broad femur interferes with rounding; rarely, and only after mild affections, there is lengthening of the neck; thinning of the joint space which is uncommon. (Although such an occurrence is rare, it may also take place early in the process when an infectious arthritis preceding the coxa plana has been unusually severe.)—*R. S. Bromer.*

OVERTON, LEWIS M., and GHORMLEY, RALPH K. Congenital fusion of the spine. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 929–934.

The authors report 4 cases of congenital fusion of the spine. All 4 patients were young at the onset of symptoms. In each case the chief complaint was painless kyphosis, whereas all other symptoms were localized, either to just above or below the fused region, and were attributed to undue strain at these points. There were no findings to substantiate the presence of an inflammatory lesion, and in no case was there a history of tuberculosis, typhoid fever, measles, scarlet fever or any other infection which might have been an etiologic factor. Roentgenograms revealed fusion of only the anterior halves of the vertebral bodies with rather marked localized kyphosis. The posterior half of the intervertebral discs and the nuclei pulposi were intact and apparently normal in all cases. There was no reaction around the fused area, either in the soft tissues to suggest a healed abscess, or in the bone to suggest an inflammatory process.

Overton and Ghormley were unable to find any cases previously reported in which the fusion was limited to the anterior half of the vertebral body. In one of their cases bilateral undescended testes were associated with the fusion, but in all the others the spinal fusion was the only abnormality which could be found.

In searching for an explanation of the fusion, in view of the lack of evidence of an inflammatory process, the involvement of only the anterior half of the bodies suggests a developmental anomaly. This would account for the slow progressive kyphosis, because the absence of the growth centers in the anterior half of the body results in a lack of growth in this portion, while the posterior half grows normally. This condition may have its origin in incomplete cleavage of the segmental scleromes, with failure to differentiate that portion which forms the anterior half of the intervertebral disc; thus the anterior half of the disc fails to form or, as Steindler suggested, the cause may be a localized arrest of growth at a very early developmental stage when the spinal column still forms an unsegmental cartilaginous rod. The condition may be classified in the group in which there is the Klippel-Feil syndrome and absence of the lumbosacral disc.—*R. S. Bromer.*

WAGNER, LEWIS CLARK. Congenital defects of the lumbo-sacral joints with associated nerve symptoms. *Am. J. Surg.*, Feb., 1935, *27*, 311–327.

The author comprehensively discusses 12 different types of congenital anomalies of the lumbosacral region, with their treatment. Detailed illustrative case reports are included.—*W. R. Brooksher.*

JOHNSON, ROBERT W. Posterior luxations of the lumbosacral joint. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 867–876.

Johnson states that while spontaneous spondylolisthesis has been known for nearly a century, the reverse subluxation of the fifth lumbar vertebra backward on the top of the sacrum has not yet been clearly described. The latter consists of a slight slipping of the body of the fifth lumbar backward, so that the posterior border of the body can be seen to overhang the top of the first sacral body by about 0.5 cm. in an accurately centered lateral roentgenogram. The articular facets of the fifth lumbar vertebra seem to be displaced downward and posteriorly, which would decrease the fifth lumbar vertebral foramen and this would seem to be one of the factors in the production of the symptoms. The intervertebral disc may or may not be flattened or irregular, and the question as to the integrity of the nucleus pulposus cannot, in the author's opinion, be absolutely determined in all cases by roentgen examination, but seems to be inconstant. The lumbosacral angle also is inconstant,

being variably increased, normal, or decreased. The presence of appreciable congenital malformation of the bones is often noted, but is not an essential concomitant finding. Johnson believes that his cases confirm the opinion that the above described appearance is due to an actual genuine type of subluxation and is not due to an artefact of roentgenography. He presents his cases in this paper as a presentation of a new phase of the low-back-pain problem, to be further studied, rather than an attempt to advance an incomplete solution of it. He advises conservatism in the treatment, although operative fusion has been required in some cases and will doubtless increase in favor. In seeking a cause of the condition, the rôle played by relaxation of the intervertebral disc or rupture of the nucleus pulposus must be carefully considered, as must also congenital malformations in the neighborhood.—*R. S. Bromer.*

Smith, Alan Def. Posterior displacement of the fifth lumbar vertebra. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 877–888.

In proportion to its frequent occurrence and its importance as a cause of low back pain, posterior displacement of the fifth lumbar vertebra on the sacrum has received surprisingly little attention. In some instances in the literature its existence is denied and there appears to be a rather widespread belief that posterior displacement does not occur. Smith's study is based on 56 cases; 36 of the patients were males, 20 were females. The average age at which they presented themselves for treatment was 31.6 years, but the average age of onset of symptoms was twenty-nine years. The youngest patient was nine years old and the oldest was sixty-four.

Smith believes that the most important single factor in determining posterior displacement is the structure of the lateral articulations between the fifth lumbar and the first sacral vertebrae. Trauma plays but a secondary part and can cause a displacement only if a certain mechanical set-up is present. In general, the plane of the articular facets at the lumbosacral junction conforms quite closely to the others in the lumbar region, the only difference being a slightly greater obliquity. The articular facets of the first sacral vertebra face internally with a slight posterior inclination and are concave. In many individuals, however, these facets face more nearly anteroposteriorly than laterally and the articulations take the form of those in the dorsal region. In these cases, moreover, the facets are usually smaller and instead of being concavo-convex, have a flat surface. This type of joint is less stable and very easily permits a downward and posterior movement of the fifth lumbar on the sacrum. Also the lateral articulations between these bones are often asymmetrical, one having the normal lateral and the other the abnormal anteroposterior inclination.

The posterior displacement is not necessarily great, and it seems quite probable that an actual sprain of the ligaments of these joints can easily be produced. In the great majority of the patients some degree of posterior displacement was present regardless of the position of the patient, but in one, no displacement was found in the recumbent position but it was present to an extent of one-fourth of an inch when the patient was standing. In several others the degree of displacement was increased when the trunk was extended and diminished or actually disappeared when the trunk was flexed.

An important secondary factor in causing the condition is diminution in thickness of the intervertebral disc, probably through rupture of the nucleus pulposus. Posterior displacement was not present in all patients showing thinning of the disc, and Smith regards oblique or anteroposterior articulations as a probable necessary concomitant.

Pain, very often severe, was the outstanding symptom. In 27 cases its onset was sudden; in 25 it was gradual. In 15 the pain began definitely after an injury. A history of repeated severe attacks of pain was common. The occurrence of pain after assuming certain positions—such as bending, stooping, etc.—was frequent. Attacks might last from a few days to several weeks. The pain was located low in the back, in other cases it radiated to other parts of the body. Smith considers radiation of pain along part or the whole of the sciatic distribution as a striking and characteristic feature of the symptomatology. This may probably be explained by pressure upon the fifth lumbar root in the canal formed by the pedicles and the lateral articulation. In 3 patients weakness and numbness in one or both legs was found and one patient had an almost complete paralysis of the muscles of the left leg supplied by the peroneal nerve which gradually disappeared after a spinal fusion operation.

Smith believes that radiation of pain cannot be relied upon to differentiate sacroiliac from lumbosacral conditions, and states that in his experience radiating pain of a type that by many is regarded as typical of a sacroiliac arthritis has been caused by a lumbosacral lesion. The decisive and important factor in the diagnosis is the roentgenogram. This must include a good lateral view which is taken exactly in the lateral plane. A slight shift of the tube is enough to produce the appearance of a posterior displacement when none exists or to conceal the presence of one. A lateral view with the patient standing and others with the trunk flexed and extended, taken by the technique developed by Ferguson, have also been found very useful.

Conservative measures seldom cure the symptoms from posterior displacement of the fifth lumbar and, in the majority of cases, lumbosacral fusion is the only effective means of treatment.—*R. S. Bromer.*

ABRAMSON, DANIEL, ROBERTS, SUMNER M., and WILSON, PHILIP D. Relaxation of the pelvic joints in pregnancy. *Surg., Gynec. & Obst.*, March, 1934, *58*, 595–613.

Relaxation of the pelvic joints, and particularly of the symphysis pubis, is a normal accompaniment of pregnancy. Hisaw demonstrated the presence of relaxin, a special fraction of corpus luteum hormone, in the blood of guinea pigs, dogs, cats, sows, mares and rabbits during pregnancy, which acts synergistically with theelin to cause a relaxation of the pelvic ligaments. The facts concerning the process of symphyseal relaxation in pregnant women indicate a very close parallel to those found by Hisaw in certain mammals and strongly suggest some type of hormonal control.

In a rather large series of measurements, the authors found the average width of the symphysis to be 4.09 mm. in nulliparas, 4.15 in uniparas, and 4.6 in multiparas. In the multiparous women the margin of the pubic bones at the symphysis are irregular with occasional small round areas of decreased density suggesting cyst formation, and there is thinning and absorption of the cortical layer at the pubic margin as contrasted with the multiparous women. The average width of the symphysis in the male pelvis was 4.4 mm. in the same age group as that of child-bearing women. The average width of the symphysis in pregnant women was 7.7 mm., an increase of 3 mm. over the average width of a similar non-pregnant group. The maximum was 20 mm. and the minimum 3 mm. Abnormal separation of the symphysis pubis occurs in about 25 per cent of the cases and probably results simply from an exaggeration of the normal physiological process; only exceptionally does trauma play any part.

The process of relaxation begins in the first half of pregnancy, suggesting that it is a physiological rather than a mechanical process. The measurements show very little increase of the relaxation in the last two or three months of pregnancy. The process of parturition seems to have very little effect in further increasing the width of the symphysis. Retrogression of the symphyseal relaxation began in the first month post partum and apparently was fairly well complete by the end of three to five months.

Pubic mobility, that is, movement of one pubic bone upon the other, could almost invariably be demonstrated by having an assistant push on one leg and pull on the other and then reversing the procedure.

Symptoms of pelvic instability may be referable to the pubic joint alone, to the sacroiliac joints alone, or to a combination of both. The pubic symptoms are the more common and consist of pain, tenderness in the region of the symphysis, occasionally referred down the inner side of the thighs, usually worse when beginning to move after sitting or lying. A waddling gait is frequently noted and in the patients showing this a positive Trendelenburg sign can usually be demonstrated. The severity of the symptoms corresponds in a general way to the amount of separation of the symphysis demonstrable roentgenologically, although this relationship was by no means constant, wide separation being at times non-symptomatic. The majority of patients begin to complain of symptoms in the last two months of pregnancy.

Treatment of abnormal separation of the symphysis is indicated to relieve symptoms and to prevent the development of a condition of chronic relaxation of the pelvic joints which is frequently responsible for a great deal of later discomfort among women who have borne children.—*J. H. Vastine.*

SAGEL, JACOB. Acute osteomyelitis (osteitis) of the patella. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 959–963.

In the case here reported by Sagel the roentgenographic diagnosis of osteomyelitis of the

patella was made early in the course of the disease, one week after the onset of the symptoms and is believed by him to be the earliest diagnosis made of this condition. His patient followed the general rule that suppuration in the knee joint does not occur, but that aseptic effusion is common, this being proved by aspiration of the joint. Etiologically his case fell into the large group of primary hematogenous osteomyelitis secondary to trauma. He has followed the patient for four and one-half years after the onset of the disease, the end-result being excellent.

The roentgenographic findings are characteristic. Destruction of the patella is shown by areas of rarefaction and mottling. Sequestra are commonly seen within these rarefied areas. Quite often there is a break in the contour of the anterior or posterior surface of the patella. Soft tissue swelling, anterior to the patella, is generally found. If there is fluid within the knee joint, the patella will be displaced anteriorly.

Most cases occur between the ages of five and fifteen years, because ossification and circulation of the patella do not begin until four or five years of age. The ratio of males to females is five to one. Injury has been established as the cause in more than half of the cases of primary hematogenous osteomyelitis of the patella. The vessels that supply it are very small, so that emboli tend to remain in the main channel (main artery) rather than be diverted by the slow moving shunt stream into the patella. As a rule, the knee joint is not affected but an aseptic effusion occurs quite commonly. The diagnosis is rarely made at the onset of the disease and usually not until a discharging sinus occurs. A good functional result will be obtained if operation is done early.—*R. S. Bromer.*

Jansson, Gösta. Zur Kenntnis der Skelettveränderungen bei der Schüller-Christian'schen Krankheit. (Changes in the skeleton in Schüller-Christian's disease.) *Acta radiol.*, 1934, *16*, 59–73.

The author describes and illustrates a case of Schüller-Christian's disease which in addition to the characteristic defects in the cranial and thigh bones showed destruction of a thoracic vertebra. The xanthomatous spondylosis was accompanied by a paravertebral shadow which looked exactly like that of the gravity abscesses that occur in tuberculous spondylitis. A shadow like that of gravity abscess has never been reported in xanthomatous spondylosis before. The author believes it was caused by a paravertebral accumulation of masses of lipoid granulations.—*Audrey G. Morgan.*

Geschickter, Charles F., and Lewis, Dean. Tumors of tendon sheaths, joints, and bursae. *Am. J. Cancer*, Sept., 1934, *22*, 96–126.

The authors review the pathology of tumors of the tendon sheaths, joints, and bursae. The different types of tumors are briefly described and there are excellent roentgenograms and photomicrographs reproduced. They conclude that the common neoplasms of the tendon sheath are benign osteochondroma, ganglion and giant-cell tumor. These tumors show a relationship to precartilaginous tissue. Fibroma, lipoma, hemangioma and lymphangioma also may occur. Tumors of the tendon proper and sarcoma are rare. Chondrosarcoma at or near the insertion of tendon into bone and fibrosarcoma of the tendon sheath have been described.

The most frequent tumors in the joint are benign osteochondromas or chondromas involving the synovia diffusely (osteochondromatosis) and giving rise to multiple loose bodies. Cysts and cartilaginous free bodies of questionable neoplastic nature may arise from the articular cartilages. Xanthomatous giant cell tumors occur in the synovia, occasionally eroding the articular cartilage and invading bone. They apparently arise in mesenchymal condensations at the primordium of the sesamoids and resemble similar tumors within the tendon sheaths. Fibromas, fibrosarcomas, and lipomas have been described.

Bursal tumors are rare. Only 30 cases could be collected from the literature and from the records of this laboratory. Benign and malignant chondromatous lesions and spindle cell sarcoma predominate. The prepatellar bursae are most often affected.—*J. H. Harris.*

Campbell, Willis C. Endothelial myeloma. *J. Bone & Joint Surg.*, Oct., 1934, *16*, 761–780.

Campbell's paper is based on 23 cases which present factors more or less suggestive of endothelial myeloma, divided as follows: (1) endothelial myeloma, confirmed by the Registry of Bone Sarcoma, 11 cases; (2) endothelial myeloma not submitted to the Registry of Bone Sarcoma, 6 cases; (3) unclassified sar-

coma, confirmed by the Registry of Bone Sarcoma, 3 cases. In 3 more cases a final diagnosis of inflammation was made and the author places those in a separate class on account of their value from a differential diagnostic standpoint.

A review of the roentgenograms of the 17 cases of endothelial myeloma demonstrated that there were eleven tumors in the shafts of the long bones, two near the ends of the long bones, one (patient aged fifty-one) on the end of the bone, one in the ilium, one in the rib, and one in the pubic bone. The changes in the shafts were characteristic in the young, and may be described in three different stages: (1) condensation of the shaft of the bone without reaction of the periosteum; (2) the typical invasion with expansion, striation and destruction of the cortex, the reactive bone production of the periosteum in layers (onion peel) being readily identified; (3) disintegration of the periosteal layers and shaft with extension of the tumor to surrounding parts. The remains of the periosteum were easily recognized by marked lipping near the junction of the normal shaft and the tumor. Lipping, which is described as one of the chief characteristics of osteogenic sarcoma, is also of equal, if not more frequent occurrence in Ewing's tumor. Bone spicules at right angles to the long axis of the shaft were found in 2 cases—a reaction more frequent in osteogenic sarcoma in the young. This reaction may also be observed in inflammatory lesions and in syphilis.

In summarizing his review of the literature, Campbell states that: (1) there seems to be a difference of opinion as to the actual existence of any type of endothelioma; (2) there is no agreement as to the histogenesis of Ewing's tumor; (3) the suggestion has been made that it could be a metastatic lesion; (4) on account of the resemblance to lymphatic tissue and the reaction to irradiation, it is suggested that the tumor may be some type of lymphosarcoma or reticulo-endothelioma; (5) as endothelium is found in low grade inflammatory tissue, and the symptoms often closely resemble acute inflammation, infection has been suggested as a possible etiological factor.

The macroscopic or gross pathology differs as do the roentgen findings. In the first stage, as demonstrated by the roentgenogram, only condensed bone may be observed; and within the marrow cavity the tissues may resemble grossly low grade inflammation, as denoted by hyperemia, and possibly slight increase of connective tissue, as found in osteomyelitis of Garré. Specimens taken from the cortex and marrow may show characteristic tumor tissue, but this can be easily overlooked. In the second stage, the tumor, consisting of grayish-white, rather firm tissue, will be found between the layers of periosteum and within the distended cortex and in the marrow. Also there are usually necrotic areas with liquefaction, hemorrhage, and disorganization which may resemble pus. Such material may fill the marrow cavity and lead to errors in diagnosis. In the third stage the tumor breaks through the periosteum and is of the character usually defined in textbooks as "grayish-white, lobulated, with areas of necrosis." In some instances there is extensive destruction so that a large portion is of brain-like consistency, more or less pigmented from repeated hemorrhages.

Of the 17 cases which Campbell lists as registered and not registered with the Registry of Bone Sarcoma, there were 4 in which there had been operations for acute osteomyelitis. An analysis of 2 of these cases reported in detail, illustrates that (1) the blood findings should suggest a condition different from the average case of acute osteomyelitis; (2) the roentgenogram may not be indicative of any one certain lesion, but in other instances it may be typical of endothelial myeloma; (3) there is necessity for accurate records, regardless of symptoms; (4) there is the necessity of making a culture and microscopic examination of all pathological tissue.

The symptoms of intermittent pain with swelling are not limited to Ewing's tumor; they are also found in syphilis, osteomyelitis of Garré, subacute and low grade osteomyelitis and osteogenic sarcoma. Only in the osteomyelitic type of syphilis should there be any confusion. In osteomyelitis of Garré there is often a history of a sudden onset with a slight elevation of temperature, but no recurrent attacks, the symptoms being more or less continuous; when remittent there is no sudden increase of swelling or elevation of temperature. Moreover both in the roentgenogram and at operation, the osteomyelitis of Garré is predominantly productive with condensation and spindle-shape enlargement and proliferation of the periosteum. In the first stage of Ewing's tumor there is condensation, but no expansion.

In the second stage there is proliferation of the periosteum, but with no destructive changes in the shaft. The suggestion has been made that osteomyelitis of Garré is Ewing's tumor in which healing by nature has occurred, but there is no evidence to substantiate such a statement. Errors in diagnosis in mistaking acute osteomyelitis for endothelial myeloma are not usually made during the initial attack, but in subsequent attacks when the symptoms closely resemble the former. In Ewing's tumor where there has been an open operation with infection and a draining sinus, differentiation is difficult. Osteogenic sarcoma can usually be differentiated by the history and the roentgenogram, for in it the shaft is intact through the tumor, and there is often bone production a considerable distance from the shaft, but within the tumor. In both conditions there is lipping but it is much more marked in Ewing's tumor. Several cases have occurred in which metastatic carcinoma has produced lesions which closely resemble endothelial myeloma.

Radium and roentgen irradiation are the only known remedies that have a definite beneficial action on the evolutionary process of the condition; therefore they should be used, before and after, or without radical operation. The tumor responds to both radium and roentgen irradiation, but the latter is of more value as it is generally more accessible. Irradiation as a diagnostic agent is most valuable and should generally be employed. The value of foreign body protein, such as Coley's toxins, is not yet determined.—*R. S. Bromer.*

Connor, Charles L. A further consideration of Ewing's sarcoma. *Am. J. Cancer*, Sept., 1934, *22*, 41–51.

A discussion of the origin of Ewing's sarcoma is given by the author based upon 3 cases. He concludes that endothelioma of bone is much like the malignant endothelioma found elsewhere; that it does not respond rapidly and readily to roentgen treatment but disappears gradually and slowly as compared, for instance, with a metastatic lymphosarcoma or a neuroblastoma in bone, but at the same time much more rapidly and surely than an osteogenic sarcoma or the average metastatic carcinoma. Endothelial myelomas are extremely difficult to differentiate from metastatic lymphomatous tumors. The absence of lymph node involvement and the fact that Ewing's tumor metastasizes to the lungs are helpful aids in the diagnosis. He gives proof that the tumor cell of Ewing's sarcoma can become an osteoblast and form bone.—*J. H. Harris.*

Bergstrand, Hilding. Osteitis fibrosa of Recklinghausen, heterotopic parathyroid adenoma, metastases of a benign adenomatous struma and adenoma of the left adrenal in the same patient. *Am. J. Cancer*, July, 1934, *21*, 581–587.

The author reports the case of a woman, aged sixty-four, who suffered a fracture spontaneously in the lower left humerus, the roentgenogram showing grave changes of a multicystic nature in the fracture site. The patient had a high blood calcium, she suffered from vomiting which was difficult to control, and she finally became apathetic and anemic, dying seven weeks after the injury.

At autopsy a partly calcified, encapsulated solitary adenoma the size of a plum was found in the thyroid. The parathyroids were normal. Numerous tumor metastases were found in the lungs, the largest nodule being the size of a pea. In the lowest part of the thymus was a tumor the size of a pigeon's egg. The tumor was brown and soft. A pedunculated polypus was found on the lesser curvature of the stomach.

Microscopic sections showed the adenoma of the thyroid to be circumscribed by a fibrous, partly calcified capsule with no evidence of malignancy. The parathyroid struma in front of the heart had an appearance which had been noted in several other cases of von Recklinghausen's osteitis fibrosa. Sections from the adrenal revealed a small encapsulated adenoma of well-known structure. In the kidneys were vast deposits of calcium. The metastases in the lungs showed the picture of a parenchymatous thyroid adenoma. The tumor of the humerus was uniform and the structure resembled a struma colloides, with large follicles filled with colloid. Slides from different parts of the skull, the spinal column and the tubular bones showed everywhere the osteolytic process characteristic of osteitis fibrosa Recklinghausen.

Metastasizing adenoma in the thyroid is a rare affection, and the case described is interesting from many points of view. The presence of adenomata in three internal secretory glands points to an embryonal disturbance as the basis of them all, this view being supported by the fact that the parastruma originated in a hetero-

topic fifth parathyroid gland. The position of this down on the pericardium is remarkable but easily explained as aberrant parathyroid tissue which may be found anywhere in the thymus. The parastruma in this case has given rise to an osteitis fibrosa Recklinghausen of a type which the author has previously described.

Adenomata are occasionally found in the parathyroids at autopsy. These differ from the usual parathyroid tissue in two ways: there is practically no fat in the actual tumor cells, and there are no fatty cells in the interstitial tissue. In other words, the tumor tissue is structurally the same as that of the normal parathyroid gland of a new-born infant. Some thyroid adenomata are, as we know, quite analogous to this.—*Wendell C. Hall.*

Milch, Henry. Giant cell tumor of the spine. *Am. J. Cancer*, June, 1934, *21*, 363–367.

The number of reported cases of giant cell tumors involving the spine is notably small. All portions of the spine appear to be liable to the disease, although the lumbar spine is most frequently involved, and relatively few times is the cervical spine involved.

The author reports a giant cell tumor of the spinous process of the third cervical vertebra in a boy sixteen years of age. The posterior portions of the adjacent laminae were also involved.

Giant cell tumors are usually located in the spongy bone and give the impression of being a characteristic, almost a specific, disease of the spongiosa. Whether the giant cell tumor is considered as a true neoplasm or is looked upon as of the nature of a tissue reaction to injury or inflammation, it would seem that it represents for the most part an affection of the spongiosa and that other parts of normal bone do not ordinarily react in this manner. It is interesting to observe that these tumors have been described as arising in the body, the spine, and the transverse processes; i.e., in those places where muscular attachments normally occur, but never in the pedicles or the laminae. Indeed the very attachment of the muscles has been considered as mediating the trauma to which some attribute the origin of these tumors. Where the pedicles or laminae are involved, it is apparently only by extension of the disease process.

The symptoms are those due to the tumor formation and those due to pressure upon the spinal cord or the peripheral nerves. The tumor may or may not be palpable, depending upon its position in the spinal column and its position in the vertebra itself. Symptoms and signs range from various types of sensory disturbance to more or less complete paralyses, and even to complete section of the cord.

Especially when the bodies of the vertebrae have been involved, these tumors have been mistaken by competent orthopedic surgeons for tuberculosis, tumors of other types, low grade osteomyelitis, and osteo-arthritis. When the growth is situated in the spines or transverse process, the roentgenogram is usually characteristic, as in the long bones. When the body of the vertebra is primarily involved, the influence of weight-bearing and the collapse of the internal structure of the bone may completely efface the typical picture and lead to difficulties in diagnosis. In such cases the diagnoses may be attempted by bone puncture, by biopsy, or by observing the reaction to roentgen therapy.

The simplest and probably the safest method of diagnosing and treating these tumors is by roentgen rays or radium. Conservative therapy is indicated where the body of the vertebra is involved. When the tumor is located in the spine or transverse processes. when paralysis is progressive, and when, inlegal terminology, "time is of the essence," surgical intervention to relieve pressure, with subsequent radiotherapy, would seem to be the method of choice. —*Wendell C. Hall.*

Wenger, F. Wie heilen Knochendefekte? (How do defects in bone heal?) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1934, *50*, 562–569.

Areas of bone destruction do not always heal by reparative formation of new bone but often the defect persists and the internal structure of the bone adapts itself to it so that there is no decrease of function. Persistence of the defect after roentgen therapy does not mean, contrary to the diagnostic evidence, that the treatment was without effect. In this method of healing the defect in the bone is surrounded by a thick shell of bone filled with scar tissue which is later replaced by fat marrow in which a filigree-like spongiosa develops which has nothing to do with the static condition of the skeleton. When the defect in bone is near the joint

cartilage the bone displaces cartilage. Bone for local reasons may be full of lime, particularly around encapsulated masses of detritus.—*E. T. Leddy.*

Kewesch, E. L. Über hereditäre Verschmelzung der Hand- und Fusswurzelknochen. (Hereditary fusion of the bones of the hand and foot.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1934, *50*, 550–556.

The author states that (1) fusion of the bones of the hand or foot results from a hypoplasia of the joints. (2) This hypoplasia of the carpal and tarsal bones analogous to the stiffening of the joints of the fingers is due to congenital and hereditary anomalies. (3) Inheritance follows Mendelian laws and is independent of sex. (4) Fusion of the carpal bones has no effect on the function of the hand. (5) Fusion of the tarsal bones produces static deformity of the foot. Kewesch illustrates some typical cases of these lesions.—*E. T. Leddy.*

Hummel, R. Zur Frage der Festigung von Spontanfrakturen bei Karzinommetastasen im Knochen. (Union of spontaneous fractures caused by metastatic carcinoma in bone.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1934, 529–537.

Hummel reports 3 cases of pathologic fracture of long bones from carcinoma metastasis in all of which some union of the fracture occurred without treatment. The formation of new bone was demonstrated roentgenologically in all these cases. All three were autopsied. There was fibrotic degeneration of the bone marrow, and the remnants of cortex were infiltrated by cancer cells. New bone often surrounded islands of cancer. Union resulted from the proliferation of this bone. Occasionally normal callus formation was present.—*E. T. Leddy.*

BLOOD AND LYMPH SYSTEM

Hutter, Karl. Zur Röntgendarstellung von Beckengefassen bei urologischen Fällen. (Roentgen demonstration of the pelvic vessels in urological cases.) *Acta radiol.*, 1935, *16*, 94–98.

As a general rule, the pelvic veins cannot be demonstrated by the injection of contrast medium into the veins of the legs; at best this method is only partially successful. The vascular and circulatory conditions in the genitourinary region are of special importance in prostatectomy as one-half of the deaths from pulmonary embolism are due to thromboses in the perivesical venous plexuses. The deep veins of the pelvis can be demonstrated by injecting contrast medium into the veins of the scrotum and penis.—*Audrey G. Morgan.*

ROENTGEN AND RADIUM THERAPY

Quiney, James J. Hyperthyroidism treated by irradiation. *Pennsylvania M. J.*, April, 1935, *38*, 480–483.

The only contraindications to the radiation treatment of hyperthyroidism are in those patients who are extremely toxic, or who are suffering from pressure effects. The advantages as stated by Pfahler are quoted. The author discusses his plan of procedure and technique, detailing the results that are to be expected. An early increase in weight during treatment indicates a good prognosis. Recovery was obtained in 89.7 per cent, while failure occurred in only 2.4 per cent of 73 cases reported by the author.—*W. R. Brooksher.*

Farrell, John T., Jr. Roentgen therapy versus surgery in the treatment of hyperthyroidism. *Pennsylvania M. J.*, April, 1935, *38*, 484–486.

Farrell calls attention to the more general availability of competent roentgen therapy and stresses the convenience of this mode of treatment in hyperthyroidism as compared with surgery. Roentgen therapy is practically devoid of danger whereas the complications of surgery are numerous and of serious import. Myxedema is not infrequent following surgical procedure; it has seldom been reported following irradiation. The end-results of the two methods are essentially the same and in the case of failure with one method, the other may often be employed to effect a cure.—*W. R. Brooksher.*

Lund, Charles C. Comparison of apparent end results in cases of carcinoma of the mouth in relation to length of follow-up. *Am. J. Cancer*, Oct., 1934, *22*, 335–341.

This statistical study attempts to determine what mathematical ratio exists between the number of apparent one year cures and the five year cures in the same group of cases. Such a ratio, if one exists, would be helpful in

evaluating newer, rapidly changing techniques of treatment, especially irradiation. It is obvious that the percentage of five year cures will always be lower than the one year percentage. Some patients will die from causes other than cancer or will be lost. Others with apparent cures will have recurrences. The author found that the death rate from intercurrent disease was in close approximation to the death rate calculated for patients of this age. The death rate from new primary cancer was three times the calculated rate. He found the number of patients apparently cured declines from one-fourth to one-half between the one year and five year periods. Patients studied were divided into five groups: carcinoma of the mouth treated by surgery and irradiation, carcinoma of the lip treated by surgery and irradiation and a small group in which the combined treatment was used. Three different treatment periods were used: 1918–1920, 1921–1923, and 1924–1926.—*J. H. Harris.*

BYCHOWSKY, M., FRANKEL, J., and EISENBERG, M. Röntgenstrahlen als Mittel für die Bekämpfung des Diphtheriebazillenträgertums. (Roentgen rays as a means for combatting diphtheria carriers.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1934, *50*, 586–588.

The authors report on a group of 96 cases in whom a satisfactory result was produced. The patients had a single treatment of each side of the throat. Children received 10–15 per cent H.E.D., through 4 mm. aluminum, adults 25–30 per cent H.E.D. through 0.5 mm. zinc+1 mm. aluminum. Smears were taken a week after treatment and the patients were dismissed when three smears were negative. The authors advocate the method as being quite certain of results (70–78 per cent of cases), cheap, safe and easy. The results are less favorable in those patients who have tuberculosis, as they have a lowered resistance to infection.—*E. T. Leddy.*

MARTIN, HAYES E. The fractional or divided dose method of external irradiation in the treatment of cancer of the pharynx, tonsil, larynx and paranasal sinuses. *Acta radiol.*, 1935, *16*, 1–24.

The author, who is attending surgeon at the Memorial Hospital in New York, gives a detailed description of the techniques and treatment factors used in that hospital in the Head and Neck Service since 1931. Using the divided dose principle, over 300 cases of pharyngeal and laryngeal cancer have been treated by roentgen rays at 200 kv., at 700 kv., and the 4 gram radium element pack. The types of cases treated, the various treatment factors and the technique of treatment in the individual case are all discussed in detail.

The author believes that an attempt at exact duplication of Coutard's treatment factors and technique is neither necessary nor advisable, as identical equipment is seldom available. The universal use of the divided dose method of radiation therapy has undoubtedly been hindered by attempts at exact duplication of Coutard's technique and a disregard of the logical application of the more important general principles.

A table is given showing the results of the cases treated in 1931 and 1932. The cases for 1933 and 1934 are not included as being too recent. Among the 140 cases treated during the period considered, 30 cases, or 21 per cent, remained free of disease on July 1, 1934. Ten of these have been free of disease for from three to three and a half years, the others for from one and a half to three years. The prognosis is better in females than in males. Of the males treated in 1931, 15 per cent are living and free of disease and of the females 44 per cent. The average ages of the successful and unsuccessful groups are about the same with a slightly higher average in the successful group. The prognosis is at least as good if not better in old age.

In 1931 the largest successful dose was 2×3,200 r in fourteen days in 3 cases of carcinoma of the extrinsic larynx, tonsil and nasopharynx respectively. The smallest successful dose was 2×2,000 r in fourteen days in one case of carcinoma of the tonsil. The largest dose in an unsuccessful case was 2×2,600 r and the smallest 2×1,600 r with several under 2×2,000 r. In 1932 the average successful dose was between 2×3,000 r and 2×3,500 r with more than 2×4,000 r in several successful cases. The average dose was much smaller in the unsuccessful than in the successful cases, showing that too small doses are apt to be given rather than too large ones. The larger doses beyond doubt produce greater reactions and are followed by longer periods of

convalescence but they are also followed by a larger percentage of cures.

The prognosis in the general group of pharyngeal tumors is influenced less than would be expected by the histological type. What seems to be a fairly radioresistant tumor histologically may regress rapidly and completely and lympho-epithelioma or transitional cell carcinoma may prove resistant to the heaviest doses.

It would be of great interest and value if the cause of the unsuccessful results could be determined but this has been impossible. Some of the failures were due to errors in the direction of the beam.

The divided dose method may be used to advantage in any form of radiation therapy and at the present time it is being used at the Memorial Hospital in a large percentage of cases where a combination of external and interstitial irradiation is planned from the beginning. According to this plan instead of giving 2 or 3 massive doses of external irradiation followed by interstitial irradiation, multiple daily doses are given over a period of two or three weeks followed immediately by the implantation of radon gold seeds. By this combination of methods a large bulky tumor may be reduced to one-half or one-fourth of its original size, thereby greatly reducing the necessary dose of radon implants. A number of cases have been treated successfully by this method.—*Audrey G. Morgan.*

Coventry, W. A., and Moe, Russell J. Ten years of surgery for cancer of the breast. *Minnesota Med.*, March, 1935, *18*, 131–134.

The authors studied 106 cases treated by 26 different surgeons between the years 1919–1933, it being assumed that 63 per cent of these patients were operated upon by experienced surgeons. Ninety-two patients had roentgen therapy in some form either preoperatively or postoperatively. In 90 per cent of these cases it was used postoperatively only; 67 cases had no roentgen therapy. Of the 92 patients treated by roentgen irradiation, 17 had lived for five years or more; of the 67 who did not receive roentgen irradiation, 16 have a five year survival. Of those patients in the series who have died, those receiving roentgen irradiation lived an average of $2\frac{1}{2}$ years after operation, while those not so treated lived an average of $2\frac{1}{3}$ years. The authors state, however, that the value of roentgen therapy cannot be accurately judged from this report since there was no selection of cases, no routine of therapy or uniformity of dosage. In their opinion radical surgery is the most effective treatment for cancer of the breast.—*W. R. Brooksher.*

Hicken, N. Frederick. The management of thyroid malignancies. *Nebraska M. J.*, Feb., 1935, *20*, 52–58.

The scientific treatment of thyroid malignancies presupposes a clear concept of their etiology, their pathological characteristics, their manner of dissemination and their physiological response to irradiation. In only 45 per cent of a series of 264 cases of malignant goiters were the physical signs and symptoms sufficiently distinctive to warrant even a preoperative suspicion of carcinoma. The author discusses the various lesions as found in the thyroid, and presents illustrative case reports. The lymphosarcomas, the malignant adenomas, and the papillary adenocarcinomas are radiosensitive, while the spindle cell sarcomas, the carcinoma sarcomas and the scirrhous carcinomas are radioresistant. Complete removal of the neoplasm is always to be desired and a combination of surgery and irradiation (roentgen ray) is more effective than either agent alone. Recurrences are to be treated by excision and intensive irradiation. Active surgical and roentgen therapy is not contraindicated in the presence of metastatic lesions.—*W. R. Brooksher.*

Crossen, H. S. Treatment of cancer of the cervix uteri. *Am. J. Surg.*, March, 1935, *27*, 389–391.

As a practicing surgeon, Crossen discusses the advantages of irradiation over the radical operation, a surgical procedure which he has abandoned. In carcinoma of the cervix, the most effective treatment can only be given by the physician with special gynecologic training in addition to radium training. Operative work is not excluded by radium therapy, but must supplement and not supplant the latter.

Present efficiency and future progress in the cure of cancer of the cervix are predicated upon the following facts: (1) The successful care of a patient with cancer of the cervix is based upon an organized combination of expert services. (2) The crucial point of attack is not the

uterus but the cancer cells along the pelvic wall. It is these outlying cells that must be reached and destroyed, or recurrence is certain. (3) Irradiation is the most important factor in attaining success in this concerted attack on the outlying cancer cells. (4) Too many patients are still being treated with half-way measures, with operations that never reach the outlying cancer cells, and inefficient radium and roentgen-ray treatments that carry no devitalization into the distant crucial zone.—*W. R. Brooksher.*

STORCK, AMBROSE H. Cancer: A brief résumé of methods of palliative surgical treatment. *New Orleans M. & S. J.*, April, 1935, *87*, 686–688.

Procedures available for the palliative surgical treatment of cancer, according to the indications which they are intended to meet, may be classified as follows: (1) local or regional excision operations; (2) space-increasing operations; (3) pressure-reducing operations; (4) nerve-conduction interrupting operations; (5) blood circulation reducing operations; (6) short-circuiting operations; (7) diversion operations; (8) plastic operations; (9) preliminary operations.

The effectiveness of irradiation may be considerably increased when employed in conjunction with appropriate surgical methods. Furthermore, the simultaneous or successive employment of different palliative procedures, or the repeated employment of the same types, may be of value in a single case.—*W. R. Brooksher.*

PARKES, WILLIAM R., Cancer treatment results as shown in twelve year survey at Evanston Hospital. *Surg., Gynec. & Obst.*, March, 1934, *58*, 634–638.

This is a general survey of the 453 cases of proved cases of cancer treated during the last twelve years. Seven per cent could not be traced. There were 26 per cent males, and 74 per cent females. There were 100 inoperable cases that lived an average of eleven months without treatment, and 101 received palliative treatment only. There were 15 operative deaths, or 4 per cent. A family history of malignancy was obtained in 8.3 per cent of the cases. The systems involved were breast in 27 per cent; pelvic organs in 22 per cent; genito-urinary tract in 12 per cent; large bowel in 12 per cent: upper digestive tract in 11 per cent, and buccal cavity in 5 per cent, of the 453 cases. Of the 453 cases, there were 172 cases which had been treated prior to five years ago and which could be traced, of which there was 24.4 per cent five year cures.

In the 453 cases of cancer, there were 28 sarcomata, or 6.2 per cent, of which there was only one patient surviving five years.

The author concludes from this general survey that surgery combined with some form of irradiation or diathermy gives better results than either surgery or irradiation alone.—*J. H. Vastine.*

KEYES, EDWARD L. Five year results of suprapubic radium implantation into bladder tumors. *Surg., Gynec. & Obst.*, Feb., 1934, *58*, 233–237.

This is a continuation of the histories of 31 cases of bladder tumors previously reported in 1928. The author has graded the bladder tumors as papilloma, Grade I, Grade II, Grade III, Grade IV carcinoma. There has been considerable criticism of the grading of tumors in general and bladder tumors in particular. The author's cases were reviewed and graded by the American Urological Association Carcinoma Registry and their classification rather closely paralleled the classification previously made of the cases, somewhat justifying that procedure.

All epithelial tumors of the bladder graded as I or II should be attacked as curable by fulguration, radon implantation, or cystectomy, unless moribund or otherwise inoperable. Grade III has a bad prognosis, but 23 per cent five year controls being reported by Keyes. The prognosis in Grade IV is most unfavorable. For implantation the author now uses 2 mc. radon filtered through 3 mm. of gold.—*J. H. Vastine.*

SUBJECT INDEX TO VOLUME 35

(abs) = abstract (E) = editorial

Abrodil, an experimental investigation (abs), 572
Abscess on concave surface of liver, roentgen diagnosis, 65
Acetabulum, intrapelvic protrusion of (abs), 840
Acids, modification of radiosensitivity by means of readily penetrating, 230
Allen, Bundy, 1885–1935, obituary (E), 268
  portrait, 268
American Board of Radiology, diplomates of, 114
American College of Physicians, notice of meeting, 113
American Radium Society (E), 824
  program of meeting, 551
  report of Advisory Committee on X-ray and Radium Protection, 828
  report of Committee on Education and Publicity, 829
  report of Research and Standardization Committee, 828
American Roentgen Ray Society, report of Committee on Legislature and Public Policy, 694
  resolutions presented by Committee on Legislature and Public Policy, 695
Anemia, pernicious, atrophy of mucous membrane of stomach as seen roentgenologically in (abs), 420
Aneurysm, large, of descending thoracic aorta with retropsoas extension, 59
  of pulmonary artery, four cases (abs), 417
Aorta, calcification of, as seen in roentgen spectrogram (abs), 417
  descending thoracic, large aneurysm of, with retropsoas extension, 59
  proportional roentgenologic measurements of (abs), 416
Aortitis, syphilitic (E), 264
Apparatus simplifying technique of administration of opaque enemas, especially for mucosa (abs), 571
Appendicitis, chronic, roentgen diagnosis (abs), 423
Arteriography (abs), 717
  arteriovenous fistula involving the common femoral artery identified by (abs), 132
  pulmonary, experimental study (abs), 705
Arthritis, chronic, roentgen aspects, 156
  chronic, roentgen changes in, 645
  synovial membranes in various types of, study of differential stains, 740
Arthrokatadysis of hip joint (abs), 130
Association of German Roentgenologists and Radiologists of Czechoslovakian Republic, 274
Astragalus and scaphoid, congenital fusion of (abs), 714
Azygos lobe, pathology of, and interpretation of double stripe (abs), 703
  vein, accessory pulmonary lobe of, 630

Back, disabled, pathologic basis for (abs), 713
Basedow's disease: See Goiter, exophthalmic
Bases, modification of radiosensitivity by means of readily penetrating, 230
Bechterew's disease, roentgen appearance of pelvis in (abs), 839
Béclère, Antoine, homage to, 696
Biopsy, aspiration, advantages and limitations of, 245
  electrosurgical, 248
  incisional, 238
Bladder, study of fine structure of calculi of (abs), 427
  tumors, five year results of suprapubic radium implantation (abs), 852
  urinary, diverticulum of (abs), 428
Blebs, emphysematous, 324
Blood, effect of roentgen rays on catalase content of (abs), 141
  picture, effect of borderline rays on fall of leucocytes and on blood picture (abs), 574
Body, entire, roentgen irradiation of, 670
Bone, changes in, in chronic fluorine intoxication, roentgenographic study, 577
  defects in, how do they heal? (abs), 848
  interference with growth of, and with development of breast as result of roentgen irradiation in childhood and youth (abs), 719
  lesions, roentgen study of, in malignant lymphogranuloma (abs), 716
  localized focal atrophy of, in hypophyseal and ovarian disturbances (abs), 130
  marrow, Hodgkin's disease of, without apparent involvement of lymph nodes, 73
  metastases to, from cancer of breast, effect of ovarian irradiation on, 384
  Paget's disease of, sarcoma formation in (abs), 716
  sarcoma, etiology and roentgen diagnosis (abs), 717
  tumors, primary malignant, differential diagnosis (abs), 717
  tumors, value of preoperative irradiation in (abs), 720
Bones, large, long, of extremities, tuberculosis of shaft of (abs), 716
  long, epiphyseal separation of (abs), 709
  of hand and foot, hereditary fusion of (abs), 849
Book Reviews
  Radium Treatment of Skin Disease, New Growths, Diseases of the Eyes, and Tonsils. By Francis H. Williams, 120

Das Ventrikulogramm. III. Teil. Dritter und vierter Ventrikel. Von Erik Lysholm, Bertil Ebenius, Knut Lindblom and Hans Sahlstedt, 120
Röntgenologische Beobachtungen über die Ossifikation der Patella. Von Hans Hellmer, 121
Röntgenology: The Borderlands of the Normal and Early Pathological in the Skiagram. By Alban Köhler. Translated by Arthur Turnbull, 410
The 1935 Year Book of Radiology. Diagnosis, edited by Charles A. Waters; Therapeutics, edited by Ira I. Kaplan, 411
The Principles and Practice of X-Ray Therapy. By Ffrangcon Roberts, 411
Classical Contributions to Obstetrics and Gynecology. By Herbert Thoms, 412
Skin Cancer: A Clinical Study with Special Reference to Radium Treatment. By A. H. Wolfgang Magnusson, 554
Agents of Disease and Host Resistance. By Frederick P. Gay, 555
Untersuchungen über die Möglichkeiten einer dreidimensionalen röntgenographischen Abgrenzung inneren Organe des menschlichen Körpers. By Carl Wegelius, 555
La roentgenothérapie des fibromyomes de l'utérus et des métropathies hemorragiques. By Paul Gibert, 556
L'Action des rayons ultra-violets et des rayons X sur les nerfs périphériques. By Jacques Audiat, 556
A Textbook of Roentgenology: The Roentgen Ray in Diagnosis and Treatment. By Bede J. Michael Harrison, 830
Atlas der normalen Ossifikation der menschlichen Hand. Von F. Siegert, 831
La broncografia en el estudio de la afecciones del torax. By Raul P. Blanco and Federico G. Capurro, 831
Clinical Miscellany. By Members of the Staff of the Mary Imogene Bassett Hospital, Cooperstown, New York, 832
Free Medical Care. Compiled and edited by E. C. Buehler, 832
The Liverpool Medico-Chirurgical Journal, 1935, *43*, Part 1, 832
BORDERLINE RAYS, effect of, on fall of leucocytes and on the blood picture (abs), 574
BRAIN, roentgen demonstration of cysticercus of, in epileptic attacks (abs), 286
roentgenogram of third and fourth ventricle of (abs), 286
tumors, place of radiation in treatment of cerebellar medulloblastomata, 429
BREAST, cancer, distribution of metastases of (abs), 718
cancer, effect of ovarian irradiation on bone metastases of, 384
cancer, place of interstitial irradiation in, 348
cancer, primary operable, effect of preoperative irradiation, 359
cancer, ten years of surgery for (abs), 851
carcinoma, artificial menopause in (abs), 136
carcinoma, inoperable, recurrent and metastatic, treatment, 371
carcinoma, radium therapy in bone metastases of (abs), 720
female, roentgen study of (abs), 702
indications for radical surgery of, 344
interference with development of, and with growth of bone, as a result of roentgen irradiation in childhood and youth (abs), 719
male, carcinoma of (abs), 719
BRONCHIECTASIS, bronchography and (abs), 704
roentgen picture of (abs), 704
some observations on (abs), 704
BRONCHOGRAPHY in bronchiectasis (abs), 704
BULLAE, emphysematous, 324
BURSAE, tumors of (abs), 845

CALCIFICATION of aorta as seen in roentgen spectogram (abs), 417
CALCULI in ureterocele, typical roentgenogram in (abs), 707
ureteral, rectification of errors in diagnosis of movement of, 70
urinary, study of fine structure of (abs), 427
CALVARIUM, osteolytic lesions involving, 9
CANCER from leukoplakia buccalis (abs), 719
methods of palliative surgical treatment (abs), 852
of breast, distribution of metastases of (abs), 718
of breast, effect of ovarian irradiation on bone metastases of, 384
of breast, place of interstitial irradiation in, 348
of breast, primary operable, effect of preoperative irradiation, 359
of breast, ten years of surgery for (abs), 851
of cervix uteri, histological classification, and relation between growth structure and results of radium treatment (abs), 708
of cervix uteri, treatment of (abs), 851
of pharynx, tonsil, larynx and paranasal sinuses, fractional or divided dose method in treatment of (abs), 850
of rectum, results obtained at Radium Institute of Paris in radiation therapy of (abs), 569
of rectum, results of treatment obtained at Experimental Medical Institute of Buenos Aires (abs), 570
of skin, inaccessible, technique for roentgen irradiation of, 93
of stomach (abs), 567
of thyroid, management of (abs), 851
of uterus, results of radium therapy in (abs), 568
prostatic, treatment (abs), 135
roentgen differentiation between, and diverticulitis of sigmoid (abs), 839
treatment results in, as shown in twelve year survey at Evanston Hospital (abs), 852

Carcinoma, gastric, value of polysography in early diagnosis (abs), 576
gelatinous, of duodenum, case of (abs), 568
giant rugae resembling, 204
metastatic, in bone, union of spontaneous fractures caused by (abs), 849
of breast, artificial menopause in (abs), 136
of breast, inoperable, recurrent and metastatic, treatment, 371
of breast, radium therapy in bone metastases of (abs), 720
of esophagus (abs), 702; (abs), 719
of male breast (abs), 719
of mouth, comparison of apparent end results in cases of, in relation to length of follow-up (abs), 849
primary, of female urethra, radium in, 259
primary, of jejunum (abs), 422
small, of stomach, roentgen diagnosis (abs), 567
Catalase content of blood, effect of roentgen rays on (abs), 141
Cerebrum, visualization of vessels of, by direct intracarotid injection of thorium dioxide (thorotrast), 188
Chadwick, James, portrait, 111
Chaoul, roentgen therapy by method of (E), 101
Chest, choice of certain technical factors in roentgenography of, 534
roentgen examination of, note on use of opaque plastic, 279
survey of roentgenographic technique in, 526
Children, anatomy and physiology of gallbladder in (abs), 425
Cholangiography (E), 822
Cholecystography, differentiation of confusing shadows in (abs), 424
"double-oral" method for, 200
Circulation, total, of living frog, roentgen procedure for studying (abs), 141
Clark, William L. 1876–1936, obituary (E), 270
portrait, 270
Clavicle, syphilis of, report of five cases (abs), 710
Cleidocranial dysostosis, familial (abs), 710
Coarctation of aorta in infant (abs), 705
Colon, roentgen appearance of mucosa of, in pathological conditions (abs), 422
value of double contrast enema in diagnosis of early neoplastic lesions of (abs), 838
Coxa plana and related conditions of hip (abs), 840
Craniopathy, metabolic, 30
Curie-Joliot, Irene, portrait, 111
Cyst formations of skull (abs), 702
simple, of pleura, 53
Cystic disease, congenital of lungs, 44, 604
Cysticercus of brain in epileptic attacks, roentgen demonstration of (abs), 286

David Anderson-Berry prize, 113
Diabetes, treatment by radiotherapy, 813
insipidus and osteitis deformans (abs), 131
Diagnothorine, simple technique for roentgenographic and stereoroentgenographic study of mucous folds with (abs), 571
Diphtheria carriers, roentgen rays as means of combatting (abs), 850
use of roentgen rays in treatment of (abs), 718
Diverticula of pericardium, inflammatory (abs), 566
Diverticulitis, roentgen differentiation between, and cancer of sigmoid (abs), 839
Diverticulum of duodenum, pictures simulating (abs), 420
of urinary bladder (abs), 428
Dosage in teleradium treatment at Radiumhemmet (abs), 575
Duodenum, diverticulum of, pictures simulating (abs), 420
extrabulbar ulcer of (abs), 838
gelatinous carcinoma of (abs), 568
papilloma of, 208
redundant, clinical significance (abs), 837
roentgen visibility of Vater's papilla in subject with niche of (abs), 423

Eastern Conference of Radiologists, report of meeting, 403
Echinococcus disease of liver and spleen, roentgen demonstration of path of perforation of (abs), 424
Ectrodactylia, inheritance of (abs), 711
Editorials
Roentgen therapy by the method of Chaoul, 101
Ralph Vincent Robinson, 1884–1935, 106
Heinz Langer, 1888–1935, 106
Harry Bernard Podlasky, 1883–1935, 107
Syphilitic aortitis, 264
Classification of physiologic or pathologic effects of irradiation (roentgen rays or radium), 266
Bundy Allen, 1885–1935, 268
William L. Clark, 1876–1936, 270
Roentgen therapy of acute inflammations and infections, 399
The neutron, 543
Pyogenic osteomyelitis of the spine, 690
Cholangiography, 822
American Radium Society, 824
Effect of borderline rays on fall of leucocytes and on the blood picture (abs), 574
of fractionating on the late effect, animal experiments (abs), 575
of irradiation, classification of physiologic or pathologic (E), 266
of radium chloride injections, preliminary report (abs), 571
of radium irradiation on electrophoretic velocity, viability and pH of *Escherichia coli* suspensions, 392
of roentgen irradiation on development of *Mesotaenium caldariorum* (abs), 137
of roentgen irradiation on esophagus and trachea (abs), 134

of roentgen irradiation on experimentally produced polycythemia in rats, with special reference to blood and bone marrow, 786
of roentgen rays on catalase content of blood (abs), 141
of roentgen rays on the liver (abs), 673
EFFUSIONS, pleural, three zones of simple, 57
EMPHYSEMA, pulmonary, important sequel of chronic lung lesions (abs), 415
EMPHYSEMATOUS BLEBS and bullae, 324
ENCEPHALOGRAPHY, cerebral roentgenoscopy as aid in, 790
technique of, 78
ENDOCRINE, DISORDERS, pre-adult, practical value of roentgenography of epiphyses in diagnosis of, 752
ENEMA, double contrast, diagnostic value (abs), 838
opaque, apparatus simplifying technique of administration of, especially for mucosa (abs), 571
EPILEPTIC ATTACKS, roentgen demonstration of cysticercus of brain in (abs), 286
EPIPHYSES, practical value of roentgenography of, in diagnosis of pre-adult endocrine disorders, 752
separation of, of long bones (abs), 709
EPIPHYSIS for lesser trochanter, 540
for symphysis pubis, does such exist? 541
proximal, of humerus, senile structural changes in (abs), 712
EPITHELIOMATA of lower rectum and anus (abs), 424
ERYSIPELAS CARCINOMATOSUM resembling radiodermatitis, 804
Escherichia coli, effect of radium irradiation on electrophoretic velocity, viability and pH of suspensions of, 392
ESOPHAGUS, carcinoma of (abs), 719
carcinoma and sarcoma of (abs), 702
effect of roentgen irradiation on (abs), 134
localization of bones in, by roentgenoscopy (abs), 702
ring-shaped images in neoplastic ulcer of (abs), 288
roentgen diagnosis of lesions of (abs), 288
value and evaluation of functional symptoms in cases of neoplasm of (abs), 419
ETHMOIDITIS, relationship between, and ocular disturbances, 215
EXTRAPERICARDIAL FAT BODIES, 40
EYE, relationship between ethmoiditis and disturbances of, 215
simple and rapid method for localizing metallic splinters in (abs), 143

FASCIAGRAPHY, 747
FASCIAL SPACES, air injection of, 750
FAT BODIES, extrapericardial, 40
FELTY'S SYNDROME (abs), 132
FEMUR, new method for roentgenographic examination of upper end of (abs), 570
roentgen technique for internal fixation of fractures of neck of, 226
FETUS, roentgen measurement of diameter of head of, in utero (abs), 706
FIBROMA, solitary intramural, of pylorus (abs), 421
FILTERING, secondary screening by means of (abs), 137
FINGERS of milkers, characteristic changes in (abs), 711
FISTULA, arteriovenous, involving common femoral artery identified by arteriography (abs), 132
carcinomatous, on basis of chronic osteomyelitis (abs), 131
FLUORINE INTOXICATION, chronic, bone changes in, roentgenographic study, 577
FOODSTUFFS, effect of, on emptying of normal and operated stomach and small intestinal pattern, 306
FOOT, hereditary fusion of bones of (abs), 849
FORAMINA, parietal, hereditary occurrence of enlarged, diagnostic importance, 1
FOREIGN BODIES in esophagus, localization of, by roentgenoscopy (abs), 702
FRACTURES, multiple, associated with blue sclera (abs), 715
of femoral neck, roentgen technique for internal fixation of, 226
of transverse processes of lumbar vertebrae, mechanism of, 468
spontaneous, union, of, caused by metastatic carcinoma in bone (abs), 849

GALLBLADDER, effect of peritoneal irritation on emptying time of (abs), 424
in children, anatomy and physiology of (abs), 425
modified technique for suspected disease of (abs), 424
GALLSTONES, visualization of minute, 656
GASTROINTESTINAL TRACT, contrast media and visualization of inner wall of (abs), 572
importance of roentgen examination of, when gastroduodenal perforation is suspected (abs), 837
practical device for roentgenography of, under roentgenoscopic control, 123
roentgenologic contributions to knowledge of physiology and pathology of (abs), 144
GENITAL ORGANS in men and women, tuberculosis of, roentgen therapy (abs), 569
GOITER, exophthalmic roentgen treatment (abs), 133
GROWTH CENTERS, osteochondritis of (abs), 713

HAAS, method of, size of sella turcica of children and adults as determined by (abs), 563
HAND, hereditary fusion of bones of (abs), 849
HEART, changes in size and shape of, as influenced by increases of intrapulmonary pressure as

shown by kymographic examination (abs), 418
failure, atypical roentgen appearance of pulmonary infarction in patients with, 635
hypertrophy of, in infancy, associated with thickened endocardium and coarctation of aorta (abs), 705
investigation of constancy of movements of, as seen roentgenologically (abs), 417
roentgen diagnosis of calcified thrombus of (abs), 705
roentgen kymography of, 640
roentgenographic studies of, in thyroid hyperfunction (abs), 417
sagittal, movements of, and aortic shadows with respiration (abs), 418
Hemorrhage, functional uterine (abs), 135
Heredity, importance and application of roentgen diagnostic procedures in studies of (abs), 576
Hip, coxa plana and related conditions of (abs), 840
intrapelvic protrusion of acetabulum (abs), 840
lateral view of, 282
Hip joint, arthrokatadysis of (abs), 130
History of roentgen kymography (abs), 418
Hodges, Fred M., honored, 113
Hodgkin's disease of bone marrow and liver without apparent involvement of lymph nodes, 73
Humerus, proximal epiphysis of, senile structural changes in (abs), 712
Hygroma, cystic, of neck (abs), 287
Hypertension, treatment by radiotherapy, 813
Hyperthyroidism, roentgen therapy versus surgery in treatment of (abs), 849
treated by irradiation (abs), 849

Ilium, etiology of condensing osteitis of (abs), 130
Illinois Radiological Society, 409, 829
Induration, plastic, of penis (abs), 708
Industrial diseases, Kienböck's disease of semilunar bone in relation to (abs), 712
Infants, cardiac hypertrophy in, associated with thickened endocardium and coarctation of aorta (abs), 705
chronic pneumonia associated with nutritional disturbances in, 454
exudative pericarditis in, roentgenology and anatomic studies (abs), 416
premature, viosterol in prophylaxis of rickets in (abs), 714
Infections, acute, roentgen therapy (E), 399
roentgen therapy of certain, 145
Inflammations, acute, roentgen therapy, (E), 399
gynecological, roentgen therapy of (abs), 134
International Congress for Light, 552
International Congress of the Scientific and Social Campaign against Cancer, 552
Interns, teaching of radiology to (abs), 570
Intestine, small, effect of foodstuffs on emptying of normal and operated stomach and small intestinal pattern, 306
small, human intubation studies of, 289, 300
small, observations on physiology of, in presence of calcified mesenteric lymph nodes, 316
Intestines, hypertrophic tuberculosis of (abs), 423
lack of contrast filling of cecum and ascending colon in hyperplastic tuberculosis of (abs), 422
Iodipin in lymph vessels after myelography (abs), 133
Iopax, roentgen study of knee joint with (abs), 713
Ischium, tuberculosis of tuberosity of, 490

Jejunum, primary carcinoma of (abs), 422
Joints, tumors of (abs), 845
Joliot, Frederick, portrait, 111

Kaschin-Beck's disease, roentgen picture of (abs), 713
Kidneys, cortical neoplasms, radiation therapy (abs), 135
normal variations in shape of pelves of, with possible pathological significance (abs), 427
technique in urography and roentgen picture in acute renal and ureteral stasis (abs), 707
tuberculosis of (abs), 427
tumors of (abs), 706
urography in 125 cases of acute renal and abdominal conditions (abs), 707
Kienböck's disease of semilunar bone in relation to industrial diseases (abs), 712
Knee, roentgen diagnosis of old lesions of crucial ligaments of (abs), 130
Knee-joint, visualization of, by means of iopax (abs), 713
Kymography, changes in size and shape of heart as influenced by increases of intrapulmonary pressure as shown by (abs), 418
constancy of cardiac movements studied by (abs), 417
of stomach (abs), 419
roentgen, and collapse therapy for pulmonary tuberculosis (abs), 706
roentgen, history of, and modifications of method (abs), 418
roentgen, of heart and great vessels, 640
roentgen, of lungs (abs), 567

Langer, Heinz, 1888–1935, obituary, 106
portrait, 106
Larynx, cancer, fractional or divided dose method of external irradiation in treatment of (abs), 850
observations concerning neoplasms of (abs), 288
Leg, clinical importance of venography in cases of varicose veins of (abs), 132
Lesions, osteolytic, involving the calvarium, 9
traumatic, of urinary tract, diagnosis, 218
Leukemia, treatment (abs), 134

LEUKOPLAKIA buccalis and cancer (abs), 719
LIPOID CELL PNEUMONIA (abs), 415
LITHOPEDION (abs), 426
LIVER, abscess on concave surface of, roentgen diagnosis, 65
effect of roentgen rays on (abs), 573
extract as remedy for roentgen sickness, 681
Hodgkin's disease of, without apparent involvement of lymph nodes, 73
roentgen demonstration of path of perforation of echinococcus disease of (abs), 424
LUMBOSACRAL JOINT, congenital defects of, with associated nerve symptoms (abs), 842
posterior luxations of (abs), 842
LUNG, rare case of open cystic (abs), 703
right, middle lobe of, roentgen appearance in health and disease, 721
LUNGS, accessory pulmonary lobe of azygos vein, 630
atypical roentgen appearance of pulmonary infarction in patients with heart failure, 635
chronic lesions of, pulmonary emphysema an important sequel of (abs), 415
congenital cystic, anatomical and roentgen study (abs), 703
congenital cystic disease of, 604
congenital cysts of, 44
emphysematous blebs and bullae of, 324
experimental study of arteriography of (abs), 705
lymphogranulomatosis of (abs), 414
partial filtration in roentgenography of (abs), 136
pathology of azygos lobe and interpretation of double stripe (abs), 703
phenomena of shadow attenuation and summation in roentgenography of, 772
primary sarcoma of (abs), 704
roentgen kymography of (abs), 567
significance of capillary line (abs), 705
stereoroentgenographic studies of apex of (abs), 414
LYMPH NODES calcified mesenteric, observations on small intestinal physiology in presence of, 316
function of lymphatics and, as shown roentgenologically by subcutaneous injection of thorium dioxide (abs), 576
LYMPH VESSELS, iodipin in, after myelography (abs), 133
LYMPHOGRANULOMA, malignant, roentgen study of bone lesions in (abs), 716
LYMPHOGRANULOMATOSIS of lungs (abs), 414
LYSHOLM GRID, progress in roentgen diagnosis with aid of, 697

MACH'S OPTICAL ILLUSION, well marked case of (abs), 144
MALIGNANCY, roentgen treatment of, using filtration equivalent to 5 mm. copper, 334
MARBLE BONES: See Osteopetrosis
MARIE-BAMBERGER'S SYNDROME, genesis of (abs), 840
MASTOID, research on pneumatization of, in twins, 782
roentgenogram of (abs), 287
MEASUREMENT, direct, of tube voltage in therapy machines by means of a grounded indicator (abs), 137
MEDULLOBLASTOMATA, cerebellar, place of radiation in treatment of, 429
MENOPAUSE, artificial, in carcinoma of breast (abs), 136
Mesotaenium caldariorum, effect of roentgen irradiation on development of (abs), 137
MESENTERY, common (abs), 838
METASTASES, bone, of carcinoma of breast, radium therapy of (abs), 720
of cancer of breast, distribution of (abs), 718
MICROPHOTOMETER, simple photo-electric (abs), 576
MINNESOTA RADIOLOGICAL SOCIETY, 113, 551, 829
MORPHINE SULPHATE, motor effects of single clinical doses of, in normal subjects, 289
MOUTH, carcinoma, comparison of apparent end results in cases of, in relation to length of follow-up (abs), 849
MUCOUS FOLDS, simple technique for roentgenographic and stereoroentgenographic study of, with diagnothorine (abs), 571
MYELOGRAPHY, a complication in (abs), 709
iodipin in lymph vessels after (abs), 133
MYELOMA, endothelial (abs), 845
endothelial, or Ewing's sarcoma (abs), 720
MYXEDEMA in a roentgenologist (abs), 718

NECK, cystic hygroma of (abs), 287
NEMBUTAL in treatment of radiation sickness, 522
NEOPLASMS: See also Tumors
laryngeal, observations concerning (abs), 288
of esophagus and stomach, value and evaluation of functional symptoms in cases of (abs), 419
NEUTRON (E), 543
NOBEL PRIZE awards in physics and chemistry, 111
NOMOGRAM for determining heating voltage values for hot cathode roentgen tubes (abs), 140

OBSTETRICAL DIAGNOSIS, roentgenography in, 77
OBSTETRICS, undistorted radiography in (abs), 426
ORGANS, internal, experimental study on visualization of, by means of thorotrast (abs), 572
OSGOOD-SCHLATTER'S DISEASE, pathogenesis of (abs), 130
OSTEITIS, condensing, of ilium, etiology (abs), 130
deformans and diabetes insipidus (abs), 131
fibrosa localisata of patella (abs), 714
fibrosa of Recklinghausen, heterotopic parathyroid adenoma, metastases of benign adenomatous struma and adenoma of left adrenal in same patient (abs), 847
OSTEOCHONDRITIS, adolescent, of symphysis pubis, with consideration of normal roentgen changes in symphysis pubis (abs), 712

of growth centers (abs), 713
Osteodystrophia fibrosa unilateralis (abs), 131
Osteolytic lesions involving the calvarium, 9
Osteomalacia, significance of hypertrophy and hyperplasia of parathyroid glands in (abs), 137
Osteomyelitis, acute, of patella (abs), 844
chronic, carcinomatous fistula on basis of (abs), 131
of spine, roentgen findings (abs), 131
pyogenic, of spine (E), 690
Osteopathia dysplastica familiaris (abs), 840
Osteopetrosis, case of, complicated by osteogenic sarcoma, 212
Osteopoikilosis, 495
Ovaries, effect of irradiation of, on bone metastases of cancer of breast, 384

Paget's disease of bone, sarcoma formation in (abs), 716
Pan-Pacific Surgical Association, Second Congress, 112
Papilloma of duodenum, 208
Parathyroid glands, significance of hypertrophy and hyperplasia of, in rickets and osteomalacia (abs), 137
Patella, acute osteomyelitis of (abs), 844
osteitis fibrosa localisata of (abs), 714
Pelvis, relaxation of joints of, in pregnancy (abs), 844
roentgen appearance of, in Bechterew's disease (abs), 839
roentgen demonstration of vessels of, in urological cases (abs), 849
Penis, plastic induration of (abs), 708
Peptic ulcer, perforated, results of suture of, as seen roentgenologically (abs), 420
postoperative, clinical and roentgen study (abs), 421
symptomatology of ulcer on greater curvature of stomach (abs), 421
Pericarditis, acute and chronic, roentgen observations (abs), 566
exudative, in infants, roentgenologic and anatomic studies of (abs), 416
Pericardium, inflammatory diverticula of (abs), 566
Pharynx, cancer, fractional or divided dose method of external irradiation (abs), 850
Placenta previa, roentgen diagnosis (abs), 426
Planigraphy, present status of (abs), 143
Pleura, simple cyst of, 53
Pleural effusions, simple, three zones of, 57
Pneumatization, supraorbital, as seen roentgenologically (abs), 286
Pneumonia, chronic, associated with nutritional disturbances in infants, 454
lipoid cell (abs), 415
subacute peribronchiolar (abs), 565
Pneumoperitoneum, oxygen in diagnosis and treatment of tuberculosis of genitalia, intestine and peritoneum (abs), 839
Pneumoventriculography, cerebral roentgenoscopy as aid in, 790
Podlasky, Harry Bernard, 1883–1935, obituary, 107
portrait, 107
Polycythemia, effect of roentgen irradiation on experimentally produced, in rats, 786
Polysograph, value in diagnosis of pathologic processes in stomach (abs), 576
Pregnancy, compound intrauterine and extrauterine (lithopedion) (abs), 426
relaxation of pelvic joints in (abs), 844
Prostate, cancer, treatment (abs), 135
Protection against radiation in medical roentgen departments, ionometric determinations of (abs), 138
arrangement for repacking of radium bombs (abs), 575
Pulmonary arch, widening of, as seen roentgenologically (abs), 417
Pyelovenous reflux, diagnostic importance (abs), 427
Pylorus, solitary intramural fibroma of (abs), 421

Radiation sickness, nembutal in treatment of, 522
Radiations of different wave lengths, results of capillaroscopic, capillarographic and tonometric studies of action of (abs), 574
Radiodermatitis, erysipelas carcinomatosum resembling, 804
Radiological Section, Connecticut State Medical Society, 552, 829
Radiology, teaching of, to interns (abs), 570
Radiosensitivity, modification of, by means of readily penetrating acids and bases, 230
Radium bombs, protection arrangement for repacking of (abs), 575
chloride injections, preliminary report (abs), 571
element pack, advantages and disadvantages, 508
emanation baths, amount of energy active in the tissues in (abs), 573
irradiation, effect of, on electrophoretic velocity, viability and pH of *Escherichia coli* suspensions, 392
pack, five gram, 498
packs, advantages and disadvantages, 513
Rays, artificially and naturally produced, separate and combined use of, 96
Rectum, cancer, results obtained at Radium Institute of Paris in radiation therapy of (abs), 569
cancer, results of treatment obtained at Experimental Medical Institute of Buenos Aires (abs), 570
lower, and anus, epitheliomata of (abs), 424
Reyn, Axel Lauritz (abs), 573
Ribs, roentgen study of normal and pathological satellite shadows of (abs), 564
Rickets in premature infants, viosterol in prophylaxis of (abs), 714

significance of hypertrophy and hyperplasia of parathyroid glands in (abs), 137
ROBINSON, RALPH VINCENT, 1884–1935, obituary, 106
portrait, 106
ROENTGEN apparatus, electrical train of events in high tension circuits of (abs), 138
apparatus, regulated in high voltage circuit (abs), 575
apparatus, safety device for, 834
departments, ionometric determinations of protection against radiation in (abs), 138
diagnosis, progress in, with aid of Lysholm grid, 697
diagnostic procedures, importance and applications of, in studies of heredity (abs), 576
film, importance of fog in determining quality of (abs), 139
film, serial, testing of emulsions of same manufacture as to constancy of most important properties (abs), 142
film, when is increase of sensitivity of, an actual step forward (abs), 142
films, efficient illumination, development and viewing boxes (abs), 141
films, method for correct viewing of (abs), 136
films, some experiments on toning (abs), 141
irradiation, fractional, animal experiments on effect of, on late effect (abs), 575
irradiation, fractional or divided dose method of external, in treatment of cancer of the pharynx, tonsil, larynx and paranasal sinuses (abs), 850
irradiation in childhood and youth, interference with growth of bone and development of breast as result of (abs), 719
irradiation of entire body, 670
mutations, genetic foundations of (abs), 575
rays, efficiency of scattered ray grids (abs), 138
rays, scattered, determination of filter-working of filters for, and of elimination of scattered rays by other methods (abs), 142
sensitivity, absolute chemical limitation of organic substances for testing (abs), 576
sickness, liver extract as remedy for, 681
therapy by method of Chaoul (E), 101
therapy machines, direct measurement of tube voltage in by means of grounded indicator (abs), 137
tube, electrical phenomena of high tension circuit of (abs), 140
tube, hot cathode tubes with self-regulating energy control (abs), 139
tube, hot cathode valves with a light trap and a light regulator (abs), 140
tube, improved high voltage, 818
tube, measurement of voltage on (abs), 139
tube, new continuously evacuated, for deep therapy (abs), 139
tube, nomogram for determining heating voltage values for hot cathode (abs), 140
tube with rotating anode and high temperature radiative cooling (abs), 138
tubes, differences between "Kestral" tube and other (abs), 144
tubes, fundamental differences between loading of Kestral tubes and those of other construction (abs), 144
ROENTGENOGRAM, effect of structure of focus on light and dark streaks in (abs), 141
importance of selectivity of grids as regards contrast in (abs), 141
mathematical concept of contrast in (abs), 144
measurement of contrast in (abs), 142
real and apparent in (abs), 142
ROENTGENOGRAPHY in obstetrical diagnosis, 777
integrating and automatic stabilizing apparatus for (abs), 142
of chest, choice of certain technical factors for, 534
of chest, survey of technique for, 526
of lungs, partial filtration in (abs), 136
of nasal sinuses, economical procedure in, 559
soft tissue, 474
soft tissue, new method of, 750
thorium hydroxide sols as opaque media in, 194
ROENTGENOLOGIST, myxedema in (abs), 718
ROENTGENOSCOPY, cerebral, as aid in pneumoventriculography and encephalography, 790
localization of bones in esophagus by (abs), 702
RUGAE, giant (localized hypertrophic gastritis) resembling carcinoma, 204

SARCOMA, bone, etiology and roentgen diagnosis (abs), 717
chondroblastic, case of (abs), 132
Ewing's (abs), 847
Ewing's, or endothelial myeloma (abs), 720
formation in Paget's disease of bone (abs), 716
of esophagus (abs), 702
of stomach (abs), 421
osteogenic, complicating case of osteopetrosis, 212
primary pulmonary (abs), 704
SCHÜLLER-CHRISTIAN'S DISEASE: See Xanthomatosis
SCLERA, blue, multiple fractures associated with (abs), 715
SCREENS intensifying, lack of definition in (abs), 140
SELLA TURCICA, changes in, in intracranial tumors at a distance from the sella (abs), 563
detailed considerations of roentgen study of (abs), 563
in twins, shape and dimensions of, 782
roentgen diagnosis of tumors in region of (abs), 563
size of, in children and adults as determined by method of Haas (abs), 563
SIGMOID, high and low power roentgenographic differentiation between diverticulitis and cancer of (abs), 839
SILICOSIS (abs), 414
SINUS, maxillary, roentgen and anatomical study, 586

maxillary, roentgen study of malignant tumors of (abs), 286
Sinuses, nasal, economical procedure in roentgenography of, 559
nasal accessory, research on pneumatization of, in twins, 782
paranasal, cancer, fractional or divided dose method of external irradiation in treatment of (abs), 850
Skeleton, changes in, in Schüller-Christian's disease (abs), 845
Skin, inaccessible cancer, technique for roentgen irradiation of, 93
Skull, cyst formations of (abs), 702
secondary tumors of vault of, from roentgen point of view (abs), 564
tuberculosis of flat bones of vault of (abs), 285
Spinal cord, injuries of, and its roots following dislocation of cervical spine (abs), 839
roentgenogram of spinal canal in tumors of, and in osteitis fibrosa (abs), 709
Spine, cervical, injuries of spinal cord and its roots following dislocation of (abs), 839
congenital defects of lumbosacral joints with associated nerve symptoms (abs), 842
congenital fusion of (abs), 842
differential diagnosis between infection and malignancy in cases of dorsal paravertebral mass, 591
giant cell tumor of (abs), 848
non-tuberculous infections of (abs), 712
osteomyelitis and infective spondylitis of, roentgen findings (abs), 131
posterior displacement of fifth lumbar vertebra (abs), 843
posterior luxation of lumbosacral joint (abs), 842
pyogenic osteomyelitis of (E), 690
some pathophysiological peculiarities of function of, 468
Spleen, roentgen demonstration of path of perforation of echinococcus disease of (abs), 424
Spondylitis, infective, of spine, roentgen findings (abs), 131
Stereoscopy, modern roentgen (abs), 571
roentgen, 662
Stomach, atrophy of mucous membrane of, as seen roentgenologically in pernicious anemia (abs), 420
cancer of (abs), 567
contents, influence of variations in reaction and motility of, on reaction and motility of intestinal contents, 300
effect of foodstuffs on emptying of normal and operated, and small intestinal pattern, 306
effect of peritoneal irritation on emptying time of (abs), 424
kymography of (abs), 419
roentgenologic and experimental studies of value of polysograph in pathologic processes in, with special reference to gastric carcinoma (abs), 576
sarcoma of (abs), 421
small carcinomata of, roentgen diagnosis (abs), 567
symptomatology of ulcer on greater curvature of (abs), 421
value and evaluation of functional symptoms in cases of neoplasm of (abs), 419
Stratigraphy, practical accomplishment of (abs), 143
Symphysis pubis, adolescent osteochondritis of, with consideration of normal roentgen changes in (abs), 712
epiphysis for, does such exist? 541
Synovial membranes in various types of arthritis, study by differential stains, 740
Syphilis of aorta (E), 264
of clavicle, report of five cases (abs), 710

Technique, choice of certain factors in, for chest roentgenography, 534
for roentgen irradiation of inaccessible cancer of skin, 93
in urography and roentgen picture in acute renal and ureteral stasis (abs), 707
modern roentgenographic (abs), 143
new method for roentgenographic examination of upper end of femur (abs), 570
of administration of opaque enemas, apparatus simplifying (abs), 571
of encephalography, 78
of roentgenography of nasal sinuses, economical procedure in, 559
practical device for gastrointestinal roentgenography under roentgenoscopic control, 123
roentgen, for internal fixation of fractures of femoral neck, 226
roentgen measurement of fetal head diameter in utero (abs), 706
simple, for roentgenographic and stereoroentgenographic study of mucous folds with diagnothorine (abs), 571
survey of chest roentgenographic, 526
Teleradium treatment, intensity distribution and dosage in, at Radiumhemmet (abs), 575
Tendon sheaths, tumors of (abs), 845
Thorium dioxide, function of lymphatics and lymph nodes as shown roentgenologically by subcutaneous injection of (abs), 576
Thorium hydroxide sols as opaque media in roentgenography, 194
Thorotrast, experimental studies on visualization of internal organs by means of (abs), 572
visualization of cerebral vessels by direct intracarotid injection of, 188
Thrombus, calcified cardiac, roentgen diagnosis (abs), 705
Thyroid, hyperfunction, roentgen studies of heart in (abs), 417
malignancy of, management of (abs), 851
Tissues, soft, new method of roentgenography of, 750
soft, roentgenography of, 474

TONSILS, cancer, fractional or divided dose method of external irradiation in treatment of (abs), 850
TRACHEA, effect of roentgen irradiation on (abs), 134
TRACHEOBRONCHIAL GLANDS, gigantic form of tuberculosis of, in adult (abs), 703
TRAUMA and malignant tumors (abs), 136
TROCHANTER, lesser, epiphysis for, 540
TUBERCULOSIS, hyperplastic, of intestines, lack of contrast filling of cecum and ascending colon in (abs), 422
hypertrophic intestinal (abs), 423
of flat bones of vault of skull (abs), 285
of genital organs in men and women, roentgen therapy (abs), 569
of genitalia, intestine and peritoneum, oxygen pneumoperitoneum in diagnosis and treatment (abs), 839
of shaft of large long bones of the extremities (abs), 716
of tracheobronchial glands in adult, gigantic form of (abs), 703
of tuberosity of ischium, 490
pulmonary, roentgen kymography and collapse therapy for (abs), 706
pulmonary, significant active, in apparently healthy adult (abs), 414
renal (abs), 427
TUMOR, dorsal paravertebral, differential diagnosis between infection and malignancy in cases of, 591
giant cell, of spine (abs), 848
metastasis, studies on (abs), 718
nephrogenic (abs), 706
osteoid-tissue-forming, simulating annular sequestrum (abs), 711
TUMORS, bone, primary malignant, differential diagnosis (abs), 717
bone, value of preoperative irradiation in (abs), 720
brain, place of radiation in treatment of cerebellar medulloblastomata, 429
in region of sella turcica, roentgen diagnosis (abs), 563
intracranial, changes in sella turcica in, at a distance from sella (abs), 563
malignant, and trauma (abs), 136
malignant, of maxillary sinus, roentgen study of (abs), 286
malignant, problem of treatment (abs), 133
of bladder, five year results of suprapubic radium implantation (abs), 852
of tendon sheaths, joints and bursae (abs), 845
renal cortical, radiation therapy (abs), 135
secondary, of vault of skull from roentgen point of view (abs), 564
some discrepancies and pitfalls that occur in clinical work as result of grading of, 795
spinal cord, roentgenogram of spinal canal in, and in osteitis fibrosa (abs), 709
uncommon, roentgen treatment (abs), 136
TWINS, research on pneumatization of nasal accessory sinuses and of mastoid processes and on shape and dimensions of sella turcica in, 782

ULCER, extrabulbar, of duodenum (abs), 838
neoplastic, of esophagus, ring-shaped image in (abs), 288
URETER, calculi of, rectification of errors in diagnosis of movement of, 70
URETERITIS CYSTICA, roentgen appearance (abs), 707
URETEROCELE, concrement formation in, typical roentgenogram in (abs), 707
URETHRA, female, radium in primary carcinoma of, 259
URINARY TRACT, diagnosis of traumatic lesions of, 218
UROGRAPHY, excretory, value of, in diagnosis of traumatic lesions of urinary tract, 218
in 125 cases of acute renal and abdominal conditions (abs), 707
technique in, and roentgen picture in acute renal and ureteral stasis (abs), 707
UTERINE BLEEDING, functional (abs), 135
UTERUS, cancer, results of radium therapy in (abs), 568
cervix, cancer, histological classification, and relation between growth structure and results of radium treatment (abs), 708
cervix, cancer, treatment of (abs), 851

VALSALVA EXPERIMENT, cardiokymogram in (abs), 418
VATER'S PAPILLA, roentgen visibility of, in a subject with duodenal niche (abs), 423
VEINS, direct venography in obstructive lesions of, 485
varicose, of leg, clinical importance of venography in (abs), 132
VENOGRAPHY, direct, in obstructive lesions of veins, 485
in varicose veins of leg, clinical importance (abs), 132
VERTEBRA, fifth lumbar, posterior displacement of (abs), 843
VERTEBRAL BODY, exanthomatosis with involvement of (abs), 715
VERTEBRAL COLUMN: See Spine
VESSELS, cerebral, visualization of, by direct intracarotid injection of thorium dioxide (thorotrast), 188
VIOSTEROL in prophylaxis of rickets in premature infants (abs), 714

XANTHOMATOSIS, changes in skeleton in (abs), 845
with involvement of vertebral body (abs), 715

AUTHOR INDEX TO VOLUME 35

Abbott, W. Osler, 289
Abramson, Daniel, 844
Adair, Frank E., 257, 359, 391, 519
Adam, A., 572
Åkerlund, Åke, 707
Alberti, W., 141
Allibone, T. E., 139
Altschul, W., 278, 571
Anson, Barry J., 630
Anspach, William E., 715
Arendt, Julian, 141
Ashbury, Howard Hicks, 93
Auchincloss, Hugh, 256, 344
Audiat, Jacques, 556
d'Aunoy, Rigney, 714
Azkovsky, J., 144

Bacon, Ralph D., 59
Baker, C. F., 288
Balfour, Donald C., 567
Balser, Ben H., 790
Bancroft, F. E., 139
Banting, F. G., 414
Barker, Nelson W., 485
Batson, Oscar V., 586, 771
Battigelli, Giacomo, 703
Bayer, L., 144
Becker, F., 286
Bejul, A., 423
Bendick, A. J., 790
Benner, S., 575
Berent, Fritz, 130
Berger, Horst, 575
Bergstrand, Hilding, 847
Berner, F., 424
Bertolotto, Ugo, 134
Bianchini, Allessandro, 702
Bigelow, Ruth, 409
Bishop, Francis W., 834
Bishop, Paul A., 577
Blanco, Raul P., 831
Bland, P. Brooke, 426
Blasi, Raffaele, 703
Bloch, Giorgio, 705
Blocksom, Berget H., 786
Bloodgood, Joseph C., 720
Bönniger, M., 414
Bolton, William W., 426
Bouwers, A., 143
Boyd, Douglas, 713
Boyden, Edward A., 425
Bozzetti, Giuseppe, 143
Bromer, Ralph S., 770
Bruno, G., 712
Buchner, Edward F., 426
Buisson, Paolo, 133
Bunting, C. H., 573
Burman, Michael, 712
Bychowsky, M. 850

Cameron, William H., 96, 517
Camp, John D., 485
Campbell, Willis C., 845
Cantor, Meyer O., 421
Capua, Antonio, 288
Capurro, Federico G., 831
Cardillo, Furio, 564
Carpenter, George K., 713
Carranza, F., 570
Carty, John R., 474, 747
Case, Eugene A., 804
Case, James T., 570
Cassen, Benedict, 818
Chambers, H., 708
Chang, C. P., 716
Chantraine, H., 140, 141, 142
Chodkewitsch, W., 132
Chorobski, Jerzy, 702
Clark, Daniel M., 752, 771
Clifford, Stewart H. I., 706
Coates, George, 589
Coe, Fred O., 218
Cohn, Max, 697
Cola, Giuseppe, 566, 567
Coley, William B., 720
Complani, Mario, 716
Connell, John H., 714
Connor, Charles L., 847
Conwell, H. Earle, 710
Corrigan, K. E., 548, 818
Cossali, Cesare, 711
Coventry, W. A., 851
Crane, A. W., 811
Crossen, H. S., 851
Cutler, Elliott C., 429
Czerny, L. I., 840

Dall'Acqua, Virgilio, 422
Davidson, Leonard T., 714
Davis, A. A., 423
Davis, Loyal, 702
Deacon, Alfred E., 740
Demetrovic, B., 141
Desjardins, Arthur U., 371
Determann, A., 136
Deutsch, Ladislaus, 141
Dillon, I. G., 782
Dioclès, 571
Dorrance, G. M., 518
Dotti, E., 576
Dozois, K. Pierre, 392
Dresser, Richard, 384, 391
Drüner, L., 571
Dubowyi, E. D., 718
Duffy, James J., 508
Dunham, Kennon, 415
Dyes, O., 286, 709
Dyke, C. G., 450

Ebenius, Bertil, 120
Eckel, P., 574
Eisaman, Josiah R., 777
Eisenberg, M., 850
Eliason, E. L., 709
d'Emidio, Angelo S., 720
Engelstad, Rolf Bull, 134
Ennis, LeRoy, M., 586, 589
Ettinger, Alice, 656

Farberow, 563
Farberow, B. I., 143
Farrell, John T., Jr., 849
Fay, Temple, 450
Feldman, Joel W., 714
Feldman, Maurice, 837
Fellows, Haynes H., 414
Felsenreich, Fritz, 130
Ferguson, Albert B., 840
Ferguson, James W., 662
Ferguson, L. K., 709
Firor, Whitmer B., 70
Flecker, H., 540, 541
Forssberg, Arne, 137
Foster, John H., 288
Franke, H., 142
Frånkel, J., 850
Fray, Walter W., 591
Freedman, Eugene, 44, 53, 324
Fricke, R. E., 258
Frik, K., 143
Frontz, William A., 135
Fuller, Alice H., 425

Gabor, Marcell E., 422
Gallavresi, Luigi, 142, 564
Gardner, R. A., 572
Gay, Frederick P., 555
Gefter, O. W., 718
Gellman, Moses, 130
Germann, Hch., 140
Gershon-Cohen, J., 279, 838
Geschickter, Charles F., 248, 255, 706, 845
Ghormley, Ralph K., 740, 842
Gianturco, Cesare, 409
Gibert, Paul, 556
Gilbert, Judson B., 719
Gillies, C. L., 640
Golden, Ross, 316
Goldhamer, Karl, 131
Goldstein, Leopold, 426
Goodwin, T Campbell, 415
Goriainowa, R. W., 711

Gourevitch, I. B., 782
Gratz, Charles M., 750
Gray, Howard K., 567
Graziansky, W., 713
Greenough, Robert B., 258, 389
Greenwald, Harry M., 454
Grilli, Adamo, 421
Grinberg, N. A., 718
Grossmann, G., 138, 140
Gutzeit, 421

Haagensen, Cushman D., 238, 254
Haas, L., 286, 563
Habbe, J. E., 108
Hachtel, Frank Wilson, 392
Haenisch, G. F., 719
Hamm, William G., 427
Hammarström, S., 132
Hampton, Aubrey O., 721
Hanford, John M., 238, 254
Harbin, Maxwell, 713
Harrison, Bede J. Michael, 830
Hartung, Adolph, 424
Hatzky, Kurt, 130
Haxthausen, H., 573
Healy, William P., 262
Heathcote, R. St. A., 572
Heeren, J., 705
Heinismann, J. I., 840
Hellmer, Hans, 121, 707
Hellner, Hans, 131
Henline, R. B., 427
Henshaw, P. S., 237
von Herman, J., 417, 427
Herscher, Harry, 73
Hershenson, Morris A., 424
Hertwig, Paula, 575
Hicken, N. Frederick, 851
Higgins, G. M., 137
Hiller, Robert I., 422
Hodes, P. J., 306
Hodges, Fred M., 145
Hodges, Paul C., 770
Hörtnagl, H., 703
Holst, L., 417, 423
Hook, H. H., 559
Horton, Bayard T., 132
Howarth M. Beckett, 840
Hsieh, C. K., 716
Hummel, R., 849
Hutter, Karl, 849
Hutton, James H., 813

Illick, H. Earl, 839

Jaches, Leopold, 704
Jackson, Chevalier, 702
Jansson, Gösta, 845
Johns, E. P., 704
Johnson, Clayton R., 570
Johnson, Robert W., 842
Johnston, C. G., 306
Jona, Eugenia, 133
Juris, K., 139, 142, 144

Kantor, John L., 204
Kaplan, Emanuel B., 715
Kaplan, Ira I., 411, 498, 521
Kaplan, Morris, 490
Karr, W. G., 300
Kaunitz, Julius, 57
Kautz, Friedrich G., 40
Keene, Floyd E., 135
Keith, D. Y., 134
Kerr, H. D., 212, 640
Kessler, Emma, 421
Kewesch, E. L., 849
Keyes, Edward L., 852
Kienböck, R., 566
King, Donald S., 721
Kirklin, B. R., 567
Knapp, John C., 717
Knox, Leila C., 136
Knutsson, Folke, 707
Koch, S. L., 215
Köhler, Alban, 410
Kogel, G., 576
Konzelmann, F. W., 795
Koudienko, J. M., 468
Kovacs, A., 563
Krebs, W., 839
Kruchen, C., 133
Kuhlmann, 421
Kuhlmann, Fritz, 576
Kuhns, J. G., 645
Kutzmann, Adolph A., 428

Lacassagne, A., 569
Langsam, Maurice J., 712
Laskarew, A., 132
Leddy, Eugene T., 371
Lehner, J., 576
Leistner, Kurt, 575
Leithauser, Daniel J., 421
Leitner, Z., 572
Lenz, Maurice, 390
Levine, Harold D., 705
Levy, Hyman, 635
Levyn, Lester, 323
Lewis, Dean, 845
Lewis, Lloyd G., 135
Lewis, Raymond W., 712
Linberg, Ludwig, 708
Lindblom, Knut, 120, 137
Lindenbraten, D. S., 416
Litwer, H., 142
Lo Monaco, Giovanni, 567
Lob, Alfons, 420
Lönnerblad, Lars, 709
Loman, Julius, 188

de Lorimier, Alfred A., 9
Lüdin, M., 563
Lund, Charles C., 719, 849
Lysholm, Erik, 120

McCready, J. Homer, 215
Magnusson, A. H. Wolfgang, 554
Manges, Willis F., 400
Mankowsky, B. N., 840
Markl, Jaromir, 573
Marquis, W. J., 288
Martin, Hayes E., 245, 850
Martinotti, Giuseppe, 420
Meland, Orville N., 348, 391
Mendillo, J. C., 424
Menees, Thomas O., 194
Menkes, Benedikt, 141
Merritt, E. A., 334
Merritt, Katharine K., 714
Meythaler, F., 424
Miescher, G., 575
Milch, Henry, 711, 848
Miles, J. M., 65
Miller, J. D., 194
Miller, T. Grier, 300
Miltner, Leo J., 716
Misske, B., 417
Moe, Russell J., 851
Moore, Sherwood, 30, 427
Moritz, Alan R., 565
Morrison, S. L., 645
Morrison, Theodore H., 837
Mucchi, Ludovico, 837
Müller, Konrad, 130
Müller, K. W., 139
Murphy, John T., 688
Myerson, Abraham, 188

Nathanson, Louis, 454
Nather, Fred B., 495
Neuhaus, W., 704
Newcomet, William S., 520
Nicotra, Antonino, 703
Nieman, C., 137
Noble, John F., 568
Nolte, F. A., 418
Nosaki, S., 576
Novati, Giulio C., 711

O'Neill, Dallett B., 526, 534
Ostreil, Ant., 568
Ott, Paul, 143
Ottonello, Pietro, 423
Oughterson, A. W., 424
Overton, Lewis M., 842

Palugyay, J., 419, 717
Pape, Rudolf, 420
Parkes, William R., 852
Payne, Franklin L., 135

Pendergrass, Eugene P., 1, 9, 105, 289, 306
Pepper, O. H., Perry, 1, 8
Perlman, Robert, 716
Perry, S. P., 786
Peters, M. V., 522
Peterson, Charles H., 226
Petzoldt, Herbert, 138
Pfahler, George E., 520, 804, 811
Phemister, D. B., 389
Phillips, R. F., 136
Piccinino, Guido, 422
Pickett, J. C., 713
Pinner, Max, 40
Podesta, Vittorio, 569
Pohle, Ernst A., 573
Pokorny, Lilly, 712
Pomeroy, Lawrence A., 259, 262
Price, Alvin E., 132
Prodan, M. T., 718
Putts, B., Swayne, 59

Quiney, James J., 849

Radford, Molly, 786
Raiford, Theodore S., 424
Rappaport, Israel, 772
Rathbone, R. Rhett, 334
Ratti, Arduino, 286
Ravdin, I. S., 306
Reichle, Herbert S., 565
Reinberg, S. A., 416
Reinhard, Melvin C., 513
Rendich, Richard A., 287
Reynolds, Lawrence, 264, 690, 822
Richards, G. E., 522
Rigler, Leo G., 552, 567
Roberts, Ffrangcon, 411
Roberts, Sumner M., 844
Roffo, A. H., 570
Rose, D. K., 427
Rossoni, Riccardo, 838
Rothberg, Abraham S., 714
Ruckensteiner, E., 703
Ruggles, Howard E., 323
Rummert, O., 131
Runco, Antonio, 838

Sabat, B., 418
Sagel, Jabob, 844
Sahlstedt, Hans, 120
St. Dedic, 416
Salotti, Adelchi, 574
Sanderson, Stevens S., 670
Sarasin, R., 571
de Savitsch, Eugene, 786
Schaap, C., 840
Schapiro, I. Scotty, 704
Schenck, Samuel George, 604
Schilling, K., 419
Schmidt, William H., 271
Schmiedt, E., 718
Schmitz, Henry, 390, 520
Schocken, Klaus, 142
Schöne, G., 417
Schoenfeld, John B., 132
Schons, Edward, 208
Schuster, Otto F., 714
Sharpe, W. C., 704
Shay, Harry, 838
Sheard, Charles, 137
Siegert, F., 831
Simmons, Channing, 717
Simon, Morris A., 53
Simpson, Burton T., 513
Smith, Alan DeF., 843
Smith, Harold V., 630
Soiland, Albert, 708
Sosman, Merrill C., 8, 429, 453
Spackman, Edgar W., 156
Spiegler, Gottfried, 136
Staunig, Konrad, 131
Stecher, William R., 123
Stein, Irving F., 839
Steiner, Morris, 454
Sternberg, H., 131
Stevens, Rollin H., 269, 518
Stewart, Fred W., 245, 254, 255, 388, 803
Stewart, William H., 839
Stirling, W. Calhoun, 135
von Storch, Theodore J. C., 78
Storck, Ambrose H., 852
Straus, David C., 285
Stumpf, P., 419
Sturgis, Somers H., 719

Tamiya, C., 576
Tatum, Julianna R., 710
Taylor, Grantley W., 136
Thaller, R., 139, 140, 144
Thoms, Herbert, 412
Thoraeus, R., 575
Töppner, Rudolf, 427
Torelli, Gastone, 705
Towne, E. B., 839
Tupikova, Nathalie, 786

Ude, Walter H., 426
Ungelenk, Alfred, 138
Urner, John A., 426

Vallebona, Alessandro, 704
Valsecchi Romeo, 422
Vaughan, Walter W., 429
Vaughn, Arkell M., 287
Vinson, Porter P., 702
Vischia, Quintino, 130

de Waard, R. H., 138, 141
Wachner, G., 414
Wachowski, T. J., 424
Wagner, Lewis C., 842
Walter, B., 144
Ward, Grant E., 248, 392
Warren, S. Reid, Jr., 526, 534
Warren, Shields, 718
Waters, Charles A., 135, 411
Watson, William L., 719
Weber, Harry M., 315, 702
Wegelius Carl, 556
Weinkle, Isaac N., 712
Weiss, K., 566
Weltz, G. A., 418
Wenger, F., 848
von der Weth, G., 706
Weyl, Charles, 526, 534
Whitaker, L. R., 200
Whitman, Armitage, 712
Widenhorn, Hans, 706
Wilder, R. M., 137
Williams, Francis H., 120
Wilson, Hugh M., 427
Wilson, J. Allen, 568
Wilson, Philip D., 844
Witham, Eva M., 718
Wood, Francis Carter, 255
Worschitz, F., 417, 427
Wulff, Helge B., 707

Young, Barton R., 681, 688

Zanetti, Serse, 705
Zeyss, W., 137
Zierach, H. J., 417
Zirkle, R. E., 230